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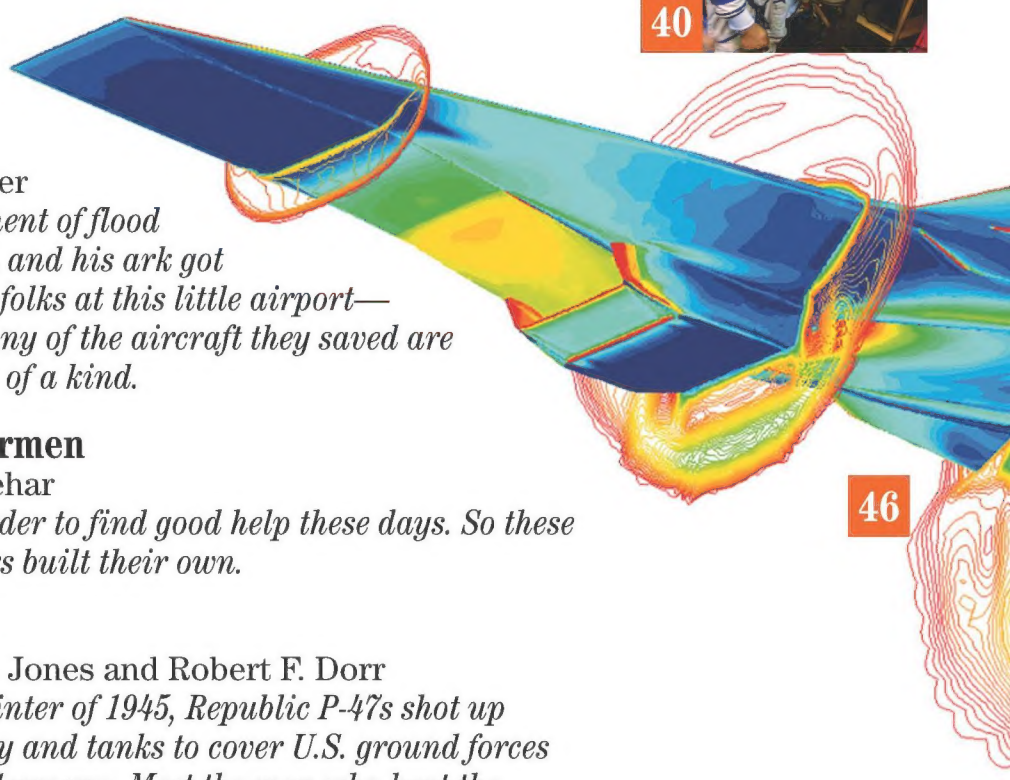
FEATURES



Cover: *Near its home at California's Mojave Airport, SpaceShipOne gives a victory salute in Chad Slattery's portrait of the spacecraft and its test pilot, Brian Binnie.*

DEPARTMENTS

We apologize that it loses 1 second every 20 million years…

The classic watch built with German precision to 1 billionth of a second?

There is a new super-accurate government device that gives you a perfect use for atomic theory. The US government has engineered the most ingenious, most accurate clock in the world, the new F-1 U.S. Atomic Clock in Boulder, Colorado. Our extraordinary new Stauer EMC^2 watch uses this clock to report the exact time from this remarkable cesium fission clock. So you are on time…all the time. This amazing clock will gain or lose only one second over a twenty million-year period. It is that accurate!

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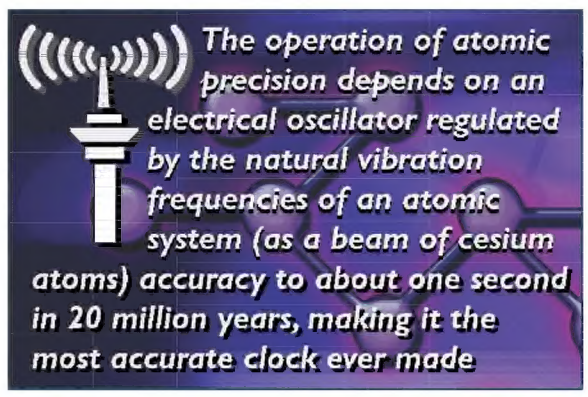
There are some unattractive plastic digital atomic watches on the market, but when our German movement maker made it possible for us to break the $100 price barrier with a beautiful, classically styled stainless steel analog watch, we were truly excited.

The EMC^2 features precise atomic time with an automatic Standard time and Daylight Saving Time adjustment. It will adjust for leap years and even leap seconds! A breakthrough in technology at a breakthrough price.

The large numeric markers are luminescent and extremely easy to read so the watch is perfect for low light situation. The EMC^2 is water-resistant to 5 atms as well. The small readout shows you the date and has a digital second counter. This watch is rugged enough to take to the gym but handsome enough to wear to the boardroom or out to dinner. The designers built this watch for those who prefer their watches to be practical and sharp-looking rather than overrated and overpriced.

How can it be so accurate? The new F-1 clock uses laser beams to measure the photons emitted from the cesium atom to measure the resonance frequency. This laser-cooling clock makes it about 20 times more accurate than any other clock on earth.



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New Milestone

In a few weeks, the National Air and Space Museum will acquire a new spaceship. Like many vehicles in the collection, this one is a winner, a record-setter, and a harbinger of the future. SpaceShipOne will arrive in Washington, D.C., barely a year after carrying a human being into space, an achievement as significant as the government-developed Mercury, Gemini, Apollo, and space shuttle programs. This one differs in that it was privately developed. Its creators are committed to a commercial venture making spaceflight safe and accessible to the public, and their ultimate goal is to open space to tourism. Someday, anyone might be able to buy a ride into space, experience weightlessness, and return safely home.

SpaceShipOne is a collaboration between legendary aircraft designer Burt Rutan and investor and philanthropist Paul Allen. Rutan turns ideas into unique winged vehicles that soar majestically—and now, rocket into space. Allen is captivated by new ideas that solve important problems and improve people's lives; he tries to anticipate what lies ahead and hasten its arrival. Rutan and Allen are focusing the power of private enterprise to shape the future of space travel.

In appearance and operation, SpaceShipOne is unlike any spacecraft in the Museum. With a fuselage faintly resembling the bullet-shaped Bell X-1 rocket plane, SpaceShipOne has distinctive swept wings with tail fins. For its initial ascent it is tucked under a graceful long-winged bird called White Knight. At 50,000 feet, SpaceShipOne is released, and the pilot ignites a hybrid rocket motor—solid rubber fuel burned with liquid nitrous oxide—for 80 seconds, enough to reach Mach 3 and 180,000 feet. The vehicle then coasts to an altitude of more than 328,000 feet.

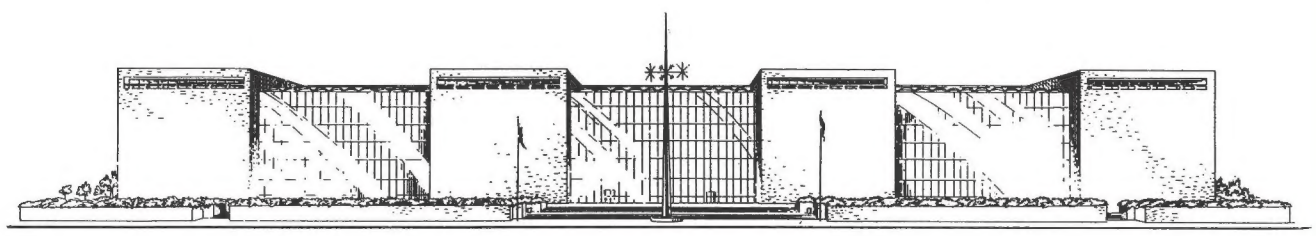
Once in space and on the way to apogee, the pilot reconfigures the craft. The twin tails and about a third of the wing tilt up, and SpaceShipOne becomes a stable "shuttlecock" for reentry into the atmosphere. While the pilot enjoys the view, the vehicle begins its descent. After the reentry deceleration, the pilot lowers the wings and tail back into position for atmospheric flight and glides to a runway landing.

Pilot Mike Melvill took SpaceShipOne to 62 miles (100 kilometers) on June 21, 2004, and to 64 miles on September 29. Brian Binnie flew it to 70 miles on October 4, 2004 (see p. 28). For the last two flights, Burt Rutan, Paul Allen, and the SpaceShipOne team won the $10 million Ansari X-Prize. They also received the 2005 National Air and Space Museum Trophy, an *Aviation Week* Laurel Award, and the 2004 Collier Trophy, as well as many other accolades.

For the achievement of suborbital spaceflight, SpaceShipOne will be displayed in the Milestones of Flight gallery, near the 1903 Wright *Flyer* and Charles Lindbergh's Ryan NYP *Spirit of St. Louis*, the Bell X-1 *Glamorous Glennis*, and the Mercury *Friendship 7*.

Its presence there affirms that the milestones of flight are not all behind us. Achievement is unending, and it is the Museum's mission to acquire, display, and preserve our most significant examples for future generations.

—J.R. Dailey is the director of the National Air and Space Museum.



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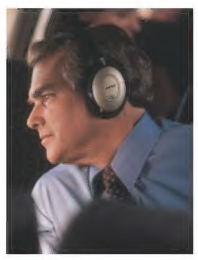

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LETTERS

Performance Grade: F

I am an aerospace engineering student in my senior year at the University of Arizona, and the final exam for my aircraft conceptual design class included several photos of the movie-prop aircraft shown in "Not Coming Soon to a Carrier Near You" (Soundings, Apr./May 2005). In the exam, we were required to evaluate the purported stealth fighter/bomber/interceptor's performance claims. Sure enough, this aircraft will fly only in movie theaters.

Eric Rosenwald
Tucson, Arizona

Comet Crisis?

"Comet Cracker" (Apr./May 2005) did not address the question of what happens to the comet nucleus' fragments after the Deep Impact probe has shattered it. Is it possible that one or more of the larger fragments could intersect our planet's orbit?

Steven E. Henigson
Eastsound, Washington

*Editors' reply: The following is from the project's Web site (*deepimpact.umd.edu/faq3.html#q5*):*

The Deep Impact impactor will just scratch the surface of the comet, making a relatively small crater compared to the size of the comet. Even if the comet were to be extremely fragile and break apart, the pieces also stay in orbits very similar to the orbit of the parent comet. Danger to the earth is from asteroids and comets whose orbits cross the earth's orbit. Tempel 1 never crosses the earth's orbit.

Maybe He Was on to Something

Was Einstein's wing really a "flub" (Oldies & Oddities, Apr./May 2005)? The description of his wing, "an airfoil with a strange mid-chord arch," sounds a lot like a laminar flow airfoil. These were used on the World War II P-51 Mustang and numerous other aircraft since. I realize the thickest part of the laminar flow wing is not at exactly mid-chord, but it's not too far from there. Maybe the great professor actually discovered laminar flow in 1916 and the engineers just didn't build his wing quite right.

Robert McL. Wiser
Kettering, Ohio

Study in Contrasts

In the 1980s, I used to have a tree farm on the east side of Air Force plant 42 in Palmdale, California. I would be out cultivating the area on a 1950s-vintage tractor and I could watch TR-1s, U-2s, and SR-71 Blackbirds leave and return from missions ("The U-Deuce," Feb./Mar. 2005). I always thought that it was an odd juxtaposition, watching these high-tech machines flying over me while I was on a much, much simpler machine.

Clark Ott
Elkader, Iowa

Looking at the magnificient photographs Chad Slattery took for "The U-Deuce," I wondered why the photograph on the cover shows no shadows, while the very similar photograph on page 21 shows long shadows.

Oscar Cosin
Valencia, Spain

Chad Slattery replies: There were broken clouds overhead and high winds aloft, so I was able to make photographs both in overcast light (the cover) and low afternoon sunlight (the inside shot).

Young but Still Charming

"Vintage Charmers" (Feb./Mar. 2005) contained a small error, reporting that the Vintage Sailplane Association accepts only gliders built through 1958. Thanks in large part to the efforts and initiative of none other than the late Paul A. Schweizer, an internationally recognized American icon to sailplane enthusiasts, VSA created a Classic Sailplane Division, which accepts certain sailplanes designed and built after 1958.

VSA recognizes the value of these classic sailplanes ("future vintage gliders") and therefore encourages the preservation of certain machines developed between the late 1950s and the early 1990s. That period saw the introduction of materials (composites) that enabled radically more efficient designs. Within about 10 years, sailplane performance more than doubled. The fine machines built in that period—for example, the Diamant, Cirrus, Phoebus, Phoenix, and Libelle—exemplify what many consider one of the most dramatic changes in aircraft design in the 20th century.

Jim Kellett
Chair, Classic Division
Vintage Sailplane Association

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LETTERS

Insensitive?

Mary Collins' assertion that German deaths in combat "don't seem as awful as the deaths of the Allied aviators" ("German Tales From the Russian Front," In the Museum, Apr./May, 2005) is the height of naïveté and arrogance. Is any death in combat less a tragedy than any other death?

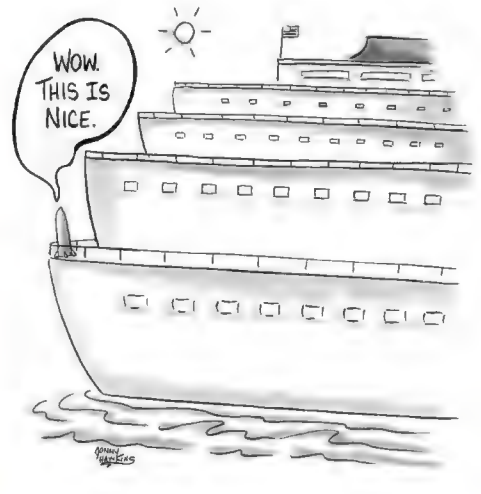
S.T. Brownell
Muscat, Oman

Every time I see the Aero L-29 or L-39 jets dressed up in the red stars of the Soviet air force ("The People and Planes of Anoka County," Apr./May 2005), I am appalled at the insensitivity of some Americans. The L-29 and L-39 were designed and built in Czechoslovakia. It is bad enough that for 40 years the Soviets stole the Czechs' work; today, some Americans continue the theft by falsely redirecting the credits for the airplane to the Russians.

K.A. Skapa
Denver, Colorado

An Uplifting Tale

"A Little Lift" (Apr./May 2005) reminded me of something I encountered while doing forest patrol work around 50 years ago in northern Idaho. I was doing most of the work at around 6,000 to 8,000 feet above sea level, flying an Aeronca with 65 horsepower, so I had to get pretty good at finding air movement that helped and avoiding that which didn't. One time I was down in a valley but wanted to exit up a slope on the downwind side of a long ridge. I found a horizontal cylinder of air rotation up against the slope of the ridge but beneath the descending airflow. I was able to climb out of there easily by



Cruise missile.

flying in close to the trees and rocks—and I mean *close*—all the while staying in the slowly rising cylinder of air.

Elwood Tresner
LaConner, Washington

The Real Reason for the Roll

Your excellent magazine usually gets it right, but I have to correct "Why does the space shuttle roll 180 degrees after it launches?" (Bar Bets, Soundings, Feb./Mar. 2005). The shuttle needs to fly to orbit on an eastward trajectory, so its tail must be pointed east. However, it takes off from the Saturn V launch pad, and because that launch pad has a flame trench running north/south, the shuttle has to be positioned on the pad with its tail facing south. After liftoff, the shuttle rolls to change its orientation from tail-south to tail-east, thus aligning its velocity vector with the desired orbital plane. The shuttle continues the roll to go upside down into orbit to reduce the wing loading during the period of maximum dynamic pressure.

Milton A. Silveira,
Former Deputy Project Manager,
Orbiter Space Shuttle
NASA Chief Engineer (ret.)

Editors' reply: The upside-down orientation also gives the flight crew use of the ground as a visual reference.

Old Slow and Inspiring

As a youngster living near Florida's St. John's River, I could watch just about every famous World War II Navy airplane fly in and out of the Navy's air station in Jacksonville. But only the Kingfishers flew low up and down the river ("Old Slow and Ugly," Feb./Mar. 2005). They may not have had the magnetism of the Hellcats or Corsairs, but watching them helped me decide to become a pilot.

Bill Pappy
Southlake, Texas

Bombers vs. Fighters (Cont'd.)

I enjoyed the tale of the B-52s going up against the fighter mafia in an air defense game ("Rogue Elephants," Feb./Mar. 2005). I suspect that the fighter jocks knew that if they didn't tie up the BUFF crews with tight restrictions, the fighters might have trouble finding them, let alone "killing" them.

Of course, just like the fighter jocks, B-52 crews have been known to have an ego problem.

Gerald P. Hanner
Papillion, Nebraska

Correction

Apr./May 2005, "Red Bull Rodeo": The large photograph on page 44 shows an Edge 540, not a Sukhoi Su-31.

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Senior Citizens

DAVID CLARK

"It will be like going to war with the Wright *Flyer* with machine guns and new propellers," an engineer fumed, referring to plans to fly the already venerable B-52 until 2040.

But the remark didn't elicit shock or outrage from the audience, just thoughtful nods and knowing smiles. After all, this was Aging Aircraft 2005, a conference sponsored by NASA, the Federal Aviation Administration, and the Department of Defense to study one of aviation's most vexing problems.

As airplanes—and spacecraft—are increasingly flown long past their original design limits, a new breed of unanticipated failures has reared its ugly head. More than 1,300 aerospace professionals congregated in Palm Springs, California, in February to confront an issue that's only now starting to be fully understood.

"We've had structural fatigue-tracking programs since the '40s," said Bob Ernst, chief of the Navy's Aging Aircraft Integrated Products Team. "But if you look at the subsystems areas, if you look at wiring diagnostics, if you look at computer software, that's all new. It's almost as if we're coming out of the primal ooze regarding aging aircraft."

Enduring platforms and legacy aircraft, as aviation dowagers are euphemistically called, occasionally make news as a result of catastrophic failure—the section of fuselage that sheared off during the flight of Aloha Airlines 243 in 1988, for example.

But more often than not, airplanes suffer the death of a thousand cuts, and the damage occurs out of sight—and out of mind. "I wish there was some way I could make corrosion prevention a sexy, exciting topic, but I'm afraid I can't," John Senter, senior vice president of Logis-Tech, said plaintively.

The four-day conference featured dozens of daunting technical sessions and dense presentations such as "Joint Time-Frequency Domain Reflectometry for Diagnostics of Coaxial Cables." If your idea of fun was listening to long disquisitions about modeling the growth rate of cracks in scratched, shot-peened aluminum, Aging Aircraft 2005 was the place for you.

Cracks and corrosion, though, are old hat. What was interesting about this year's conference was how much attention was paid to relatively fresh issues, such as wiring, which is often designed to last as long as the airplanes it serves—but not as long as airplanes are actually flying. "We have estimates that 40 percent of systems failures are caused by wiring," says Chuck Anderson of Schaffner Electrotest.

Computers are another cutting-edge concern. Because many systems were designed with integrated hardware and software, they can't be upgraded when they become obsolete. Says Vance Edwards of the Department of Defense's Microelectronics Activity: "The technology is changing so fast that it's difficult to predict how it's going to perform [in the future]."

But the biggest problem associated with aging aircraft is just getting people to spend money on them. "Does anybody like to write a check for automobile insurance?" Ernst asked, shaking his head. "Exactly. We don't like to put money into sustaining engineering."

—Preston Lerner

UPDATE

Seiran Sub Found

A research team from the University of Hawaii discovered the wreckage of the I-401 World War II submarine, designed to carry three folded-up Seiran bombers, off Oahu last March ("All and Nothing," Oct./Nov. 2001). "It's a leviathan down there, a monster," Terry Kirby, research craft pilot, told the Associated Press. The I-400 class submarines were the largest built before nuclear subs were introduced in 1959. Four hundred feet long and 40 feet high, they accommodated a crew of 144. The Seiran floatplanes were to bomb the Panama Canal.

This sub, whose aircraft had been scuttled after Japan surrendered, was sunk by U.S. forces, in part because Russian scientists were demanding access.

The Ambitious Hayabusa

Hayabusa means "falcon" in Japanese. And its falcon-like mission—to execute a quick touch-and-go on the surface of an asteroid and snatch samples of soil for return to Earth—is by far the most daring yet for Japan's burgeoning space program.

If all goes as planned, the half-ton Hayabusa spacecraft will arrive at an unassuming, potato-shaped rock called 25143 Itokawa (named for Hideo Itokawa, who is considered the founder of Japan's space program) in late August. Launched in 2003 by JAXA, the Japanese space agency, the mission is meant to test several advanced technologies, including ion propulsion and autonomous navigation using lidar to gauge the distance to its target.

Upon arrival at Itokawa, Hayabusa will park itself about six miles from the asteroid and spend three months taking pictures and mapping the surface before closing in for the grab. To avoid contamination from rocket exhaust, the craft will free-fall the last few yards down to the asteroid. The instant it makes contact, a bullet made of the element tantalum will fire from a funnel-shaped collecting horn, and the stuff that comes flying up from the resulting crater will be trapped in a chamber at the other end of the horn. The technique will be repeated up to three times at different spots on the asteroid.

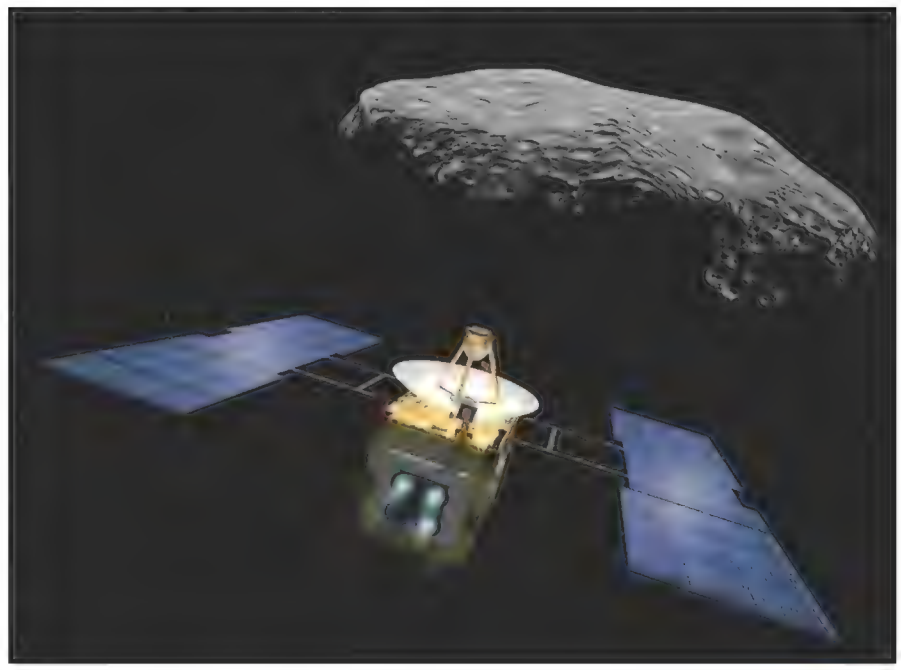
Altogether, Hayabusa will collect a mere three-hundredths of an ounce of material, which will be tucked inside a reentry capsule for a parachute landing in Woomera, Australia, in June 2007. Scientists will then compare Itokawa's chemistry and mineral content with those of meteorite samples on Earth.

For all its drama and cleverness, Hayabusa won't be the first spacecraft to touch an asteroid. NASA's Near Earth Asteroid Rendezvous (NEAR) bumped its way to a clumsy touchdown on the asteroid Eros in 2001, even though it was never designed as a lander. NASA originally planned to join in the Hayabusa mission as well, and had engineers at its Jet Propulsion Laboratory in Pasadena, California, designing a wheeled "nano-rover" for roaming around on the asteroid's surface. But that proved expensive and technically daunting, and NASA chose to back out.

For one thing, the 500-yard-long asteroid has such low gravity (.001 percent of Earth's) that wheels have a hard time generating traction. So Japanese engineers went a different route. Hayabusa carries a "jump rover" no bigger than a coffee mug, called MINERVA (Micro/Nano Experimental Robot Vehicle for Asteroid). Just before the main spacecraft starts collecting samples, MINERVA will be dropped to the asteroid, where, for a couple of days, it will use a rotating torquer mechanism to push against the surface and hop around the asteroid like a tiddlywink, taking pictures and temperature readings.

If all this seems like a technical stretch for JAXA…it is. Another Japanese mission, Nozomi, suffered an electrical problem and had to be abandoned in 2003 before reaching Mars. Yet Hayabusa was working fine just weeks away from its destination, and mission managers were hopeful that this time, the falcon will nab its prey.

—Tony Reichhardt



JAXA

"Hi there, 25143 Itokawa. Mind if I poke around for a while?" Japan's Hayabusa asteroid mission hopes for landfall on the asteroid in August, where it will gather three samples to be returned to Earth in a reentry capsule.

UPDATE

TYSON RININGER (2)

Gordon Fullerton flew many NASA B-52B missions, including its last. New symbology was added to the veritable library on its fuselage to honor the airplane's retirement (below).

Not 2 B 4gotten

NASA's B-52B mothership, which since 1960 has served as the premier carrier of a wide range of experimental aircraft ("Mother," June/July 2001), flew its last mission November 16, launching the X-43A scramjet on a modified Pegasus booster over California (see "Debrief: Hyper-X," p. 46). Though it was the oldest B-52 still flying, it had logged only 2,450 hours in its 49 years. Zero-Zero-Eight (its tail number) will be displayed at Edwards Air Force Base in California. Its replacement, a B-52H, is a mere 42 years old. At the retirement ceremony last December 17, longtime 008 pilot Gordon Fullerton noted that the most advanced piece of equipment on board was the battery-operated West Bend kitchen timer that he last used to count down to the X-43A launch. Dryden Flight Research Center workers added the Porky Pig sign-off to the dozens of mission symbols on the fuselage.

Turbo-Taxi

Imagine soaring above urban gridlock and zipping into a city center aboard a jet taxi that operates from compact air parks instead of airports. The London-based Avcen, Inc., hopes to begin flight tests of a stubby twin jet it calls the Jetpod next year and have a number of the jets in service by 2010.

"The aircraft itself was born out of probably 10 years of study into the needs analysis of customers in and around cities," says managing director Mike Dacre. Those studies led to a design that will be powered by two low-noise turbofans mounted on top of the cabin, and will have a top speed of 350 mph and capacity for seven passengers. The major breakthrough, Dacre says, is "through-wing thrust," which will redirect some of the engines' bypass thrust—the air that passes through a turbofan's blades but not through the compressors. Aimed down, the thrust will boost the Jetpod and allow it to take off in 410 feet, a fraction of the takeoff distance required by comparable aircraft.

Because of their short-takeoff-and-landing capability, Jetpods need not operate from traditional airports.

AVCEN

An artist's conception cutaway reveals a cabin full of happy Jetpod travelers.

Instead, their passengers would drive to "park and fly" sites outside the city and take Jetpods to other small landing sites in the urban center. "There would be as many as 50 of these aircraft we would see servicing a major city," says Dacre.

Because the airplanes will fly at low altitudes, Dacre says they will pose no problems for air traffic control. "This aircraft can actually fly point-to-point low level, and it will fly along pre-determined routes," he says. "I know air traffic control are really not too bothered about the aircraft as long as it stays below, say, 750 feet."

Avcen believes Jetpods could also carry troops, operate as medevacs, and even function as unmanned aerial vehicles. At a per-unit cost of $1.2 to $1.5 million, the company hopes to sell 7,000. "We're just not competing with anyone else in the market," says Dacre.

Jetpod is not the first small aircraft touted as capable of going where conventional craft can't. "The ability to land on and take off from any reasonably sized open ground with security frees the pilot from the necessity of seeking a safe landing only at the large airport," read an ad for one such craft—the Pitcairn Autogiro. The ad ran in 1932.

—Tom Huntington

The Honorees

On July 29, the U.S. Post Office will issue a pane of 20 stamps (10 designs) called American Advances in Aviation. Designed by Phil Jordan, *Air & Space/Smithsonian* founding art director, and rendered by aviation artist William Phillips, American Advances builds on the Classic American Aircraft pane of 1997, which was designed and executed by the same team. "The airplanes chosen depict American innovations and technological contributions to military, commercial, and general aviation during the 1930s, '40s, and '50s," says U.S. Postal Service spokesperson Mark Saunders. Left to right, first strip: Boeing 247, Consolidated PBY Catalina, Lockheed P-80 Shooting Star, Boeing B-29 Superfortress. Second strip: Grumman F6F Hellcat, Republic P-47 Thunderbolt, Consolidated B-24 Liberator, Northrop YB-49 Flying Wing. Third strip: Ercoupe 415, P-80 repeats, Beechcraft 35 Bonanza, followed by repeats.

The Civil Air Patrol's New Seeker

About 2,500 feet above the ground, two mechanical eyes stare through a quartz glass window in the belly of an Australian-built GA-8 Airvan. One is an ordinary video camera that delivers high-resolution black-and-white images of the scene below. The other eye is connected to a hyper-spectral imager that turns the picture of the ground into pixels of light. Then it slices across the spectrum of that light, dividing it into 60 narrow contiguous bands and spitting out a number for the brightness it sees at

each slice. A computer converts the brightness numbers to a distinctive curve that describes a spectrum—the "shape" of the reflected light—and thus reveals the color of what lies below.

Meet Archer, the Civil Air Patrol's new Airborne Real-time Cueing Hyperspectral Enhanced Reconnaissance system. In early March, Archer was rolled out at the U.S. Army's Fort Belvoir in Virginia to begin operations with the CAP's nationwide fleet of aircraft. The new sensor system will enable CAP aircraft to fly a search pattern over a patch of terrain with vastly improved odds of finding what it's looking for because of the sensor's ability to spot spectra that either match the color on an aircraft or contrast with the average spectrum of the background. The CAP conducts 95 percent of all inland search-and-rescue operations in the United States. The imaging system "will allow CAP aircraft to identify an object on the ground as small as one meter in size from half a mile in the air, even if it's partially hidden by trees or bushes," said CAP national commander Major General Dwight Wheless in a statement.

A computer does the number crunching, a Global Positioning System sensor supplies location information, and a database provides elevation for the location the aircraft is overflying. The sensor package is mounted on the floor of the Airvan, a newly acquired eight-passenger utility airplane powered by a 300-horsepower Lycoming engine. Mounting the boxy package, according to Colonel Drew Alexa, CAP director of advanced technologies, requires removal of two seats and about 90 minutes of work. Two observers ride along on a scanning mission, which involves overflying a square section of terrain in a series of back-and-forth swaths. The observers watch as the imager appears to spray-paint an aerial photo of the scene below on the computer screen. Alongside the ever-expanding map, a chunk of software is collecting and cataloging hits on objects below that either match a spectrum they're looking for or don't fit with their surroundings. The hits show up as red boxes around the object to indicate a match; anomalies get yellow boxes.

Because the system analyzes only reflected light, it works only in daylight. Images can be shared via satellite relay with ground teams, improving response time and the deployment of resources where they're most needed. Although the system could have a role in homeland security, the CAP is careful to describe it as a "reconnaissance" system and to avoid any mention of surveillance, which implies a law-enforcement role. The CAP can undertake missions such as drug enforcement when requested by civilian law enforcement agencies.

The CAP spent $5.2 million on the Archer system, a "bargain," says Alexa, because so much of the development was provided by scientists and engineers from the Air Force, Navy, and Coast Guard. For that investment, which was appropriated by Congress in 2002, they'll get 17 systems for the fleet of 16 Airvans, giving real meaning to the phrase "eyes in the sky."

—George C. Larson

RETIRED RIVALS

JOE DUNN (2)

The X-32B (left) joins the X-35C at the Patuxent River museum.

X-Planes Land at Pax River

Last March, the Boeing X-32B Joint Strike Fighter Concept Demonstration Aircraft was transferred to the Patuxent River Naval Air Museum at the Naval Air Station at Patuxent River, Maryland. The short-takeoff-and-landing variant joins the Lockheed X-35C carrier variant, which was donated to the Museum in April 2003. The X-32B and X-35C represent the beginning of the Department of Defense Joint Strike Fighter program and demonstrated that the JSF preliminary designs were viable. In 2001, the Department of Defense selected Lockheed Martin to build three variants of the F-35, for the Air Force, the Navy, and the Marines. Boeing had built two X-32 aircraft and Lockheed built two X-35s as a part of an earlier contract. The sister ship to the X-35C, known as the X-35B (the short-takeoff-and-landing variant), is on display in the Smithsonian's Stephen F. Udvar-Hazy Center near Dulles Airport in Virginia. The X-32A (Air Force and Navy variant) is in storage at a Boeing facility in Palmdale, California.

—Joe Dunn

HEADS UP

CAROLINE SHEEN

"Dude! Check Out the View!"

The Air Force One Pavilion at the Reagan Presidential Library in Simi Valley, California, will open in September, displaying SAM (Special Air Missions) 27000, the Boeing 707 that served seven presidents, as well as a Sikorsky VH-3A "Marine One" and a Grumman F-14 Tomcat. Air Force One, mounted on three elliptical concrete columns, gazes out an enormous picture window at the Santa Susanna mountains. A mezzanine-floor catwalk leads visitors around the 707 at cockpit level and over the airplane. SAM 27000 was first used by Richard Nixon in February 1973. It was replaced in 1990 by a Boeing 747 and relegated to serve as a backup. In August 2001, it made its last flight with a president, George W. Bush.

All the Pretty Things

The next time you visit the National Air and Space Museum to see your favorite airplanes, head up to the second floor at the Museum's east end. An exhibit featuring 72 works, "Generous Friends: Building an Art Collection for the National Air and Space Museum," opened last October and will be on display indefinitely in Gallery 211. The art, mostly paintings with a few sculptures, is just a fraction of the Museum's collection, which contains more than 4,000 aviation- and space-theme works, including drawings, prints, ceramics, textiles, and even jewelry. Since the Museum rarely purchases artifacts, most of the artwork was donated. Among the artists represented in the collection are Howard Chandler Christy, Jamie Wyeth, Robert Rauschenberg, and Alexander Calder.

Planted at the beginning of the exhibit is John Safer's sculpture "Challenge," a grouping of polished steel arches that the sculptor composed as a memorial to the crew of the space shuttle *Challenger*, who lost their lives shortly after the vehicle launched on the morning of January 28, 1986.

Peter Lautenslager captures the motion of flight with an acrylic painting of a Junkers W-34 floatplane, which looks as if it's about to fly into the gallery space.

An unexpectedly cute artifact is Susan Tennant's glazed earthenware sculpture of an open-cockpit triplane. The airplane's cockpit seats two amusing creatures, and other characters dance along the triplane's wings.

One of the most arresting images is Norman Rockwell's "Behind Apollo 11," a painting honoring some of the people who supported the first manned moon landing in 1969. The painting, which Rockwell worked on at a motel in Cocoa Beach, Florida, features the Apollo 11 crew—Neil Armstrong, Buzz Aldrin, and Michael Collins—standing in profile. Surrounding the astronauts are 23 people, ranging from the astronauts' wives to German rocket pioneer Wernher von Braun and Kurt Debus, then-director of Florida's Kennedy Space Center. (For a complete listing of those featured in "Behind Apollo 11," visit *www.airspacemag.com*.)

—Diane Tedeschi

Artist Peter Lautenslager captured the ruggedness of the German-built Junkers W-34, an all-metal transport widely exported during the 1920s and '30s.

BACKGROUND: ERIC LONG

Norman Rockwell painted "Behind Apollo 11," an oil on canvas, as an assignment for Look *magazine in 1969.*

In 1981, Susan Tennant used glazed earthenware to create a triplane with wingwalkers.

John Safer's polished steel sculpture "Challenge" (opposite) memorializes the crew of the space shuttle Challenger.

ARTIFACTS

Cargo King

DANE PENLAND

In 1972, Fred Smith was looking for a few good airplanes. Smith needed aircraft to launch Federal Express, a package delivery company he founded in Memphis, Tennessee. That year, he purchased two French-built Dassault Falcon 20Cs for $1.2 million each. Aircraft number N8FE, which on April 17, 1973, carried Federal Express' first air-delivered package, is now on display at the National Air and Space Museum's Steven F. Udvar-Hazy Center in northern Virginia. The Falcon 20 was a 10-seat executive jet before engineers created a cargo version by strengthening the floor, adding a cargo door, eliminating the passenger windows, increasing the size of the nose wheel, and modifying the tail. Federal Express donated N8FE, which Smith had nicknamed Wendy after his daughter, to the Museum in 1983.

MUSEUM CALENDAR

June 9 Exploring Space Lecture: "Deep Impact." In early July, the Deep Impact spacecraft will release a probe designed to crash into Comet Tempel 1, excavating a crater and enabling scientists to analyze the comet's innards (see "Comet Cracker," Apr./May 2005). Deep Impact principal investigator Michael A'Hearn will discuss the mission plan and preview the upcoming encounter. Lecture is free, but tickets are required: Call (202) 633-2398, send an e-mail to *lectures@nasm.si.edu*, or visit *www.nasm.si.edu*. Albert Einstein Planetarium, 7:30 p.m.

June 11 Family Day: "Reach for the Sky: Be a Pilot." Learn about becoming a licensed private pilot by talking to more than 25 local aviation enthusiasts, who will be on hand with their own aircraft. Visitors can also talk with Virginia Department of Aviation staff about official state aircraft on display and learn the fundamentals of flight at interactive exhibits. Steven F. Udvar-Hazy Center, 10 a.m. to 3 p.m.

Curator's Choice
Occasionally a National Air and Space Museum curator gives a 15-minute talk about an artifact or subject of interest at the Steven F. Udvar-Hazy Center. Meet at the nose of the SR-71 Blackbird reconnaissance aircraft at noon. June 2, "Recovering the Apollo 11 Astronauts"; June 16, "Balloonamania: Historic Artifacts From the 18th and 19th Centuries"; July 7, "Evolution of the Bell Helicopter"; July 21, "Kosmos 936 Artificial Gravity Experiment Package."

Saturday Star Parties
On June 25 and July 9, join National Air and Space Museum staff astronomer Sean O'Brien and other local astronomers to observe celestial objects in dark skies unpolluted by city lights. The evening begins with a short orientation of the night sky. Sky Meadows State Park, near Paris, Virginia, 8:30 p.m. to 11 p.m. Parking fee: $4 per car; park phone number: (540) 592-3556.

Except where noted, no tickets or reservations are required. To find out more, visit www.nasm.si.edu *or call Smithsonian Information at (202) 357-2700; TTY: (202) 357-1729.*

Operation Provide Feline

While I was stationed in Germany, my unit, the 512th Fighter Squadron, spent time in Turkey, participating in Operation Provide Comfort I and II in the early 1990s. Turkey has a lot of cats. The legend is that the national hero, Mustafa Kemal Atatürk, was reincarnated as a cat. The problem is, nobody knows which cat. Atatürk is Turkey's version of George Washington, Abraham Lincoln, and Benjamin Franklin all rolled into one. Nobody wants to whack a national hero, so as a result, there are plenty of cats roaming the country.

A family of cats took up residence under a shipping container outside our Squadron Operations Center at Incirlik Air Base, just outside Adana. Small, furry creatures and large, dangerous machinery do not get along well. The mom cat and one of the two kittens were killed, despite our best efforts to keep them from harm. However, the remaining kitten thrived. We adopted him as our unofficial squadron mascot and named him Dragon, which was also the squadron's nickname. The troops in the life support section were kind enough to keep him fed. Dragon would wander in and out of the operations center, enjoying the air conditioning and the company. He spent enough time in "the vault," where the classified equipment and documents were kept, that we briefly suspected him of being a Kurdistan Workers Party spy. Several weeks passed without Dragon attempting to steal or photograph anything, so we decided he was just a loyal, if curious, NATO cat.

It occurred to me that it wouldn't look good to have the F-16 contingent of Operation Provide Comfort grounded for rabies, so the base vet brought Dragon up to date on his shots.

When we were getting ready to rotate out of Turkey and back to our home base in Germany, the squadron replacing us made it clear they had no intention of caring for our mascot in our absence. A check of Germany's quarantine laws showed that vaccinations were required at least 30 days prior to importation. The departure date of the last transport bringing our squadron personnel and equipment back was only 28 days after Dragon's shots. While I knew he wouldn't be bringing rabies to Germany, I was pessimistic about the German customs agents' flexibility on the issue.

With no one to take care of him in Turkey, and no way to get him back on a regular transport, I decided to bring him back in the cockpit with me. Customs agents never bothered with single-seat fighters, and I remembered one of my German flight instructors regaling us with tales of smuggling stereo components in the nose fairings of F-104 wingtip fuel tanks. Compared to a turntable, a small cat should be easy.

Since I was single at the time and spent too much time on the road, I couldn't keep Dragon. But one of the maintenance guys had a wife and kids who could. I made sure I was on the schedule to take one of the fighters back home. It was a five-hour flight, with one mid-air refueling and some squirrelly routing due to European politics. The external travel pod was out of the

DAVID C. LARK

question, since it was unpressurized and unheated. I took a small cardboard container, cut it down to fit in the cockpit with me, knocked a few air holes in it, and lined it with one of my T-shirts. Since Dragon was only about 12 weeks old at the time, he had room in the container to move around.

I even gave passing consideration to emergency procedures. If I had to eject, and had enough time, I planned to take Dragon out of the container and stick him to my survival vest, his head below my chin, and between the ends of my horse-collar life preserver. None of the lap or shoulder belts would be under him (important for man-seat separation, and for avoiding man-cat separation after ejection), and he likely could hold on during the 14-G ejection and subsequent parachute opening. Since I'd flown about 800 hours in the F-16 without ever having to eject, I thought the five hours to Germany would pose less of a risk for him than staying in Turkey.

I wasn't sure about Air Force regulations covering the shipment of pets in fighter cockpits, but I was fairly sure my superiors would not look kindly upon the act. I told only a few guys in the squadron of my intentions: the life support techs, Dragon's adoptive family, and one or two of the pilots flying home earlier. There were several points during our trip where we could have been ratted out if the players involved didn't go along. The first test came when I arrived at my airplane to mount up. The crew chief took a look at the container next to my helmet bag and asked what it was. When I told him I was taking Dragon home, I got a thumbs-up.

Pre-flight, takeoff, and the first two hours of flight were without incident. Clouds started rolling in as we approached the tanker rendezvous. Dragon's cardboard box was on my lap and blocking my view of the instrument panel. This hadn't been a problem while we were in the clear, but now I had to move him. Not having a whole lot of room in the F-16 cockpit, I had little choice but to turn the box sideways and put it on the right console behind my elbow. Joining with the tanker and refueling in the clouds kept me fairly busy, with occasional interruptions by my passenger clawing my elbow through an air hole.

Shortly after we finished refueling, we broke out of the clouds and had good weather up the boot of Italy and through France. The next challenge came at our home field, Ramstein. I was number four in the flight of four aircraft, so I would be last to land. Ahead of me was Mongo.

Mongo was a pilot who started his career flying RF-4 Phantoms. Maybe it was because his first jet had started life as a Navy fighter, or maybe he was a frustrated naval aviator, or maybe he just really liked the movie *Top Gun*—whatever the reason, Mongo had more cable engagements than anyone else in the squadron.

Most Air Force bases have several arresting cables stretched across the runway. Unlike the cables on aircraft carriers, the ones on Air Force runways are used only for emergencies, and it takes a lot more time to clear an aircraft from them than it does to clear an aircraft on a carrier. Unfortunately, today was Mongo's day to have another brake failure and take the cable. As I executed a go-around, I called the supervisor of flying in the control tower and asked, "How long before you get Mongo out of the cable?"

"Ten or 15 minutes" came the reply.

I checked my gas gauge. "Ten, or 15?" I said. "It makes a difference." When I couldn't get anything out of him other than a "Stand by," I told him I'd call him from Pferdsfeld, our standard divert base, which was close to Ramstein.

I landed and taxied to the transient ramp to park. A German crew chief met me and hooked a ladder to the cockpit after I shut down. The first thing I handed him was Dragon, still in his container (I wasn't about to take him out now; I was afraid I'd never get him back in). When the chief asked "*Was ist das?*" I replied "*Das ist meine katze*" in a tone that implied "Aren't all German fighter pilots issued cats?" He merely shrugged his shoulders as if to say "Americans are weird" and took Dragon down the ladder.

I called home to Ramstein, and my squadron commander told me to fill the jet's internal tanks full for the short flight back. I had hoped to take on only about half that much fuel, but he pointed out that there was no way to be sure a half load would be distributed evenly in the internal tanks. Actually, the F-16 does enable the pilot to balance fuel manually, but I wasn't going to argue with the boss. Also, he didn't know I was carrying Dragon (my theory was it's easier to beg forgiveness than ask permission), so I couldn't use the cat to justify a lighter fuel load. Now I had to burn down fuel to a respectable landing weight. F-16s can't jettison fuel, so I had to burn it using a combination of steep turns, afterburner, and speed brakes (known as "burner and boards"). I didn't like putting Dragon through that, but I figured the 10 minutes of Gs would be preferable to his spending another hour in the container while I burned down fuel at a more sedate rate.

Dragon's cardboard box was on my lap, blocking my view of the instrument panel. Not having a whole lot of room in the F-16 cockpit, I had little choice but to turn the box sideways and put it on the right console behind my elbow. Joining with the tanker and refueling in the weather kept me busy, with occasional interruptions by my passenger clawing my elbow through an air hole.

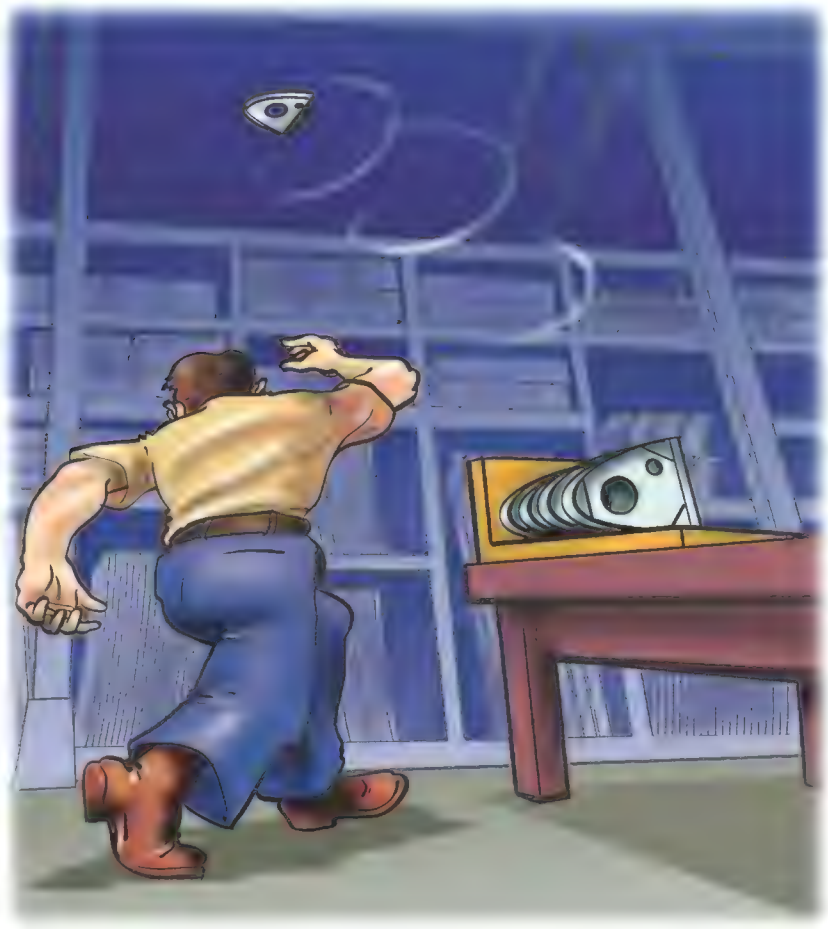
When I finally landed at Ramstein, my flight commander met me at the jet. He didn't know about Dragon either, but as soon as I hopped out of the jet, he seemed to know what the container meant. The smile on his face told me I wasn't in trouble, at least not enough to warrant documentation. I finally liberated Dragon from his container. He immediately took a potty break in the grass next to the jet's parking area.

Dragon now had a total of 5.4 hours of F-16 flight time in his logbook, plus the ground time at Pferdsfeld. Almost as impressive was the fact that my T-shirt was still dry. He hadn't urinated or gotten airsick during either flight—truly a fighter squadron's cat. Five minutes later, he was wandering around our squadron building like he owned it. Because it was so late, I took him home for the night and brought him to his new family the next day. The squadron weapons officer had a name tag made for him, with a cat silhouette in place of pilot's wings, and we displayed it in the squadron bar with the name tags of other former squadron members.

I think I know which cat is Atatürk. Just don't tell the Turks.

—Greg "Blotto" Garrett

Tear Down This Wall



WAYNE SHIPP

Many years ago, after first cautiously sticking my head out the front door of an aeronautical school, I went to work at the Douglas Aircraft plant in El Segundo, California. Working swing shift, I was initially engaged in drilling oodles of little holes in aluminum sheet. Management soon recognized my potential and promoted me to dimpling the same little holes so flush-head rivets could be installed.

Sometimes even experienced workers made mistakes. These were called "butches," short for "butchered." Douglas management went ballistic if you screwed up a part. You were to dutifully take the butched part to a supervisor, who would chastise you severely. He would make a mark in a black book that tracked each person's butches and warn you that management would not look kindly upon repeats. Early on it became apparent that you would never come out ahead, career-wise, by running to the supervisor each time you butchered an assembly. So we came up with an alternative.

The plant was enormous, nearly a mile long and a couple hundred yards wide. We worked in the department that made the leading edges of AD Skyraider wings, next to an unused section walled off by tall cabinets and large shelves. We called it The Wall. This corral held all kinds of stuff that was unused, at least temporarily. Management had turned off all the lights over the space, and since the entire plant had not one window, it was quite dark over there. No one ever went in. In fact no one could even get in, unless they were on a bulldozer.

After looking in all directions for supervisors, and determining that none were watching, a worker who had butchered a part would fling it toward The Wall. It would sail grandly in an arc, maybe 20 feet high, over The Wall and into that dark and cluttered area. No audible noise was made; there was so much noise—the pounding cacophony of riveters, dimplers, and presses—you could hardly hear yourself think, let alone hear some rinky-dink piece of aluminum hit another one.

We got used to seeing parts sailing over The Wall. Because of the success of the disposal procedure, the leading-edge butch rate plunged to near zero. Supervisors were convinced the lecturing was paying off.

Of course, the sheet metal parts and assemblies were being consumed at an alarmingly expedited rate. But in an aircraft plant of that size, and with the sheer numbers of AD Skyraiders being churned out, wing leading edges and other pieces like them were made in great quantities, and the surplus stored for future use. Managers often forgot where they put them. The individual raw pieces were turned out like popcorn, so it would be a long time before anyone noticed they were running short. Though everyone (but supervisors) was aware of The Wall, no one could see over the top into the vast interior where the butched parts trajectories' ended.

One day, management had a crew from a photo studio come in to take pictures of the factory interior for a financial report. The photographers decided that for one series of shots, they needed to be high up. Just below the roof were motorized cranes that traveled on I-beam supports. The photographers ascended in a jury-rigged basket, high above the factory floor. As fate would have it, they trundled to the area surrounded by The Wall and dangled over it.

"Stop! Stop!" one of the photographers shouted excitedly down to a worker on the floor. "Jesus! What the hell is this?" The photographer was shining his flashlight downward. "It looks like the damned North American Aviation salvage yard!" (That was a popular place for junk collectors to congregate, right next to our plant at the corner of Aviation Boulevard and Imperial Highway.)

We watched in dread a few days later when the big overhead lights came on above The Wall. Then, piece by piece, The Wall was torn down. We could, for the first time, view with mounting awe and apprehension the repository for all those ballistically disposed parts. We were aghast at what several years of hurling parts through the air had produced. Management was even more aghast at the multitudes of butched nose ribs, external-stores mounting trunnions, web sections, hat sections, and gun mount stiffeners.

Right away, the leading edge parts butch rate returned to normal—that is, abysmally high. The former parts impact zone was now wide open, brightly illuminated, and in full use. People worked there assembling landing gear. We had nowhere to throw butches, nor anything to throw them over. (One guy, just out of habit, hurled one over his shoulder. It arced expertly into the landing gear assembly area, nearly braining one of the innocents working there.)

After it was all over, management, rather than terminating us, just made sure we all remained. It was even worse than getting fired. But for management, it was better. Where else would they find another bunch of bozos willing to work for 79 cents an hour?

—O.H. Billmann

Max Stührling's big mistake

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THE NOTORIOUS FLIGHT OF MATHIAS RUST

In 1987, a West German teenager landed his Cessna in Red Square and helped up-end the Soviet defense establishment.

BY TOM LECOMPTE >>> PHOTO-ILLUSTRATIONS BY DAVID POVILAITIS

On a mild spring day in late May 1987, military analyst John Pike was at the U.S. embassy in Moscow on business when he looked out the window and saw a small airplane circling over Red Square. *Gee, that's peculiar*, thought Pike. *There's no private aviation in the Soviet Union. Hell, there's no private anything.*

The aircraft belonged to West German teenager Mathias Rust—or, more accurately, to Rust's flying club. In a daring attempt to ease cold war tensions, the 19-year-old amateur pilot had flown a single-engine Cessna nearly 550 miles from Helsinki to the center of Moscow—probably the most heavily defended city on the planet—and parked it at the base of St. Basil's Cathedral, within spitting distance of Lenin's tomb. Newspapers dubbed the pilot "the new Red Baron" and the "Don Quixote of the skies." The stunt became one of the most talked-about aviation feats in history. But it was politics, not fame, that motivated Rust.

There is nothing in Rust's neat two-bedroom apartment outside Berlin—no mementos, no photographs, no framed newspaper headlines—nothing at all to indicate that for a few short weeks 18 years ago he was the most famous pilot in the world. But the memory of the flight has stayed fresh. "It seems like it happened yesterday," says Rust, now 36. "It's alive in me."

As a child in Hamburg, Rust had been preoccupied by two things: flying and nuclear Armageddon. Belligerence and distrust marked East-West relations of the time. U.S. President Ronald Reagan seemed to be on a personal crusade against the Soviet Union. Many Germans were on edge. "There was a real sense of fear," Rust says, "because if there was a conflict, we all knew we would be the first to be hit."

To many Europeans, Mikhail Gorbachev's ascendancy to the Soviet leadership in 1985 offered a glimmer of hope. *Glasnost*, his policy of transparency in government, and *perestroika*, economic reforms at home, were rad-

Defense Minister Sergei Sokolov (with medals) was among the hundreds of military officials dismissed by Soviet Premier Mikhail Gorbachev after Mathias Rust flew undeterred into Moscow. The failure of arms reduction talks between Gorbachev and U.S. President Ronald Reagan in Iceland in October 1986 inspired Rust's flight.

W. Germans Applaud Newest 'Red Baron'

TASS/SOVFOTO AND AP/WIDE WORLD

Pilot's Parents Say Peace Was His Goal in Moscow

BONN, June 8 (Reuters)

RED SQUARE FLIGHT CALLED PEACE TRIP

Admitting His Guilt, German Tells Soviet Court of

ical departures from the policies of his predecessors. So when the U.S.-Soviet summit in Reykjavik, Iceland, in October 1986 ended without an arms reduction deal, Rust felt despair. He was particularly angered by Reagan's reflexive mistrust of the Soviet Union, which Rust felt had blinded the president to the historic opportunity Gorbachev presented.

Rust decided he must do something—something big. He settled on the idea of building an "imaginary bridge" by flying to Moscow. If he could reach the Soviet capital, if he could "pass through the Iron Curtain without being intercepted, it would show that Gorbachev was serious about new relations with the West," says Rust. "How would Reagan continue to say it was the 'Empire of Evil' if me, in a small aircraft, can go straight there and be unharmed?" Rust also prepared a 20-page manifesto he planned to deliver to Gorbachev on how to advance world peace.

Rust had taken his first flying lessons only a couple of years before his decision to fly to Moscow. A data processor at a mail-order trinket company, he spent all of his money (and some of his parents') flying. But by the spring of 1987, he had barely 50 hours of licensed flight time, and had completed just a handful of cross-country trips.

"I thought my chances of actually getting to Moscow were about 50-50," Rust says, noting that in 1983, the Soviets blew Korean Airlines flight 007 out of the sky after it strayed into Soviet airspace near the Kamchatka Peninsula; all 269 persons aboard were killed. "But I was convinced I was doing the right thing—I just had to dare to do it."

To prepare himself for his mission, he planned a practice flight to Reykjavik, the site of the doomed arms talks. It would be "a long time flying over open water with very little navigation aids," says Rust. "I figured if I succeeded, I would be able to cope with the pressure of flying to Moscow."

Rust meticulously planned his route and signed out a 1980 Cessna Skyhawk 172 from his flying club for three weeks. The four-seat airplane was equipped with auxiliary fuel tanks that boosted the aircraft's range by 175 nautical miles to 750 nautical miles—range he would need in order to safely reach Reykjavik, and later Moscow. The club didn't ask him where he was going, and Rust didn't say. He packed a small suitcase, a satchel with maps and flight planning supplies, a sleeping bag, 15 quarts of engine oil, and a life vest. As a final precaution, Rust packed a motorcycle crash helmet. The helmet was for his final leg to Moscow, "because I didn't know what [the Soviets] would do, and if I was forced down it would give me extra protection [in case of a crash]."

On May 13, 1987, Rust took off from Uetersen Airfield, outside Hamburg, and flew for five hours across the Baltic and North seas before reaching the Shetland Islands. The next day he flew to Vagar, on Denmark's Faröe Islands, in the middle of the north Atlantic. On May 15 he flew to Reykjavik.

Rust spent a week in the Icelandic capital. He visited Hofdi House, the white villa that was the site of the Reagan-Gorbachev summit. "It was locked," Rust says, "but I felt I got in touch with the spirit of the place. I was so emotionally involved then and was so dis-

AP/WIDE WORLD

RUST DECIDED HE MUST DO SOMETHING—SOMETHING BIG. HE SETTLED ON THE IDEA OF BUILDING AN "IMAGINARY BRIDGE" BY FLYING TO MOSCOW.

appointed with the failure of the summit and my failure to get there the previous autumn. So it gave me motivation to continue."

On May 22, Rust set out for Finland by way of Hofn, Iceland; the Shetlands; and Bergen, Norway. He landed at Malmi airport in Helsinki on May 25. Since leaving Hamburg, he had covered nearly 2,600 miles and had doubled his total flight time to more than 100 hours. He had proven to himself he had the flying skills he needed, but he still had doubts about his nerve. His resolve constantly wavered: Yes, it was something he had to do/No, it was crazy.

The night of May 27 was a restless one for Rust. In the morning he drove to the airport, fueled the Cessna, checked the weather, and filed a flight plan for Stockholm ("My alternate if I chickened out," he says), a two-hour trip to the southwest.

At about 12:21 p.m., Rust took off. Controllers at Malmi had him turn west toward Stockholm, asking him to keep the airplane low to avoid traffic. Although the Cessna was equipped with a transponder, a device that transmits a response to radar interrogation and thus helps to identify an aircraft, Helsinki controllers didn't assign him a setting, so he turned the device off—the controllers would track Rust's airplane by the reflection of radar signals off its metal skin. Rust held course for about 20 minutes, at which point controllers radioed to say he was leaving their control area. Rust thanked them and said goodbye.

He continued toward Stockholm for several minutes; then, as he closed in on his first waypoint, near the Finnish town of Nummela, he chose. "All of a sudden, I just turned the airplane to the left [toward Moscow]," he says. "It wasn't really even a decision.... I wasn't nervous. I wasn't excited. It was almost like the airplane was on autopilot. I just turned and headed straight across [the Gulf of Finland] to the border."

At the Tampere air traffic control facility in Finland, controllers noticed Rust's near-180-degree change of course. As the radar blip headed south and then east across the water, passing through restricted Finnish military airspace, controllers tried to contact him and failed. At about 1 p.m., Rust's airplane disappeared from radar screens. Fifteen minutes later, a helicopter pilot radioed that he spotted an oil slick and some debris on the water near where Rust's airplane was last detected. A search-and-rescue operation was activated—only to be called off when news of Rust's landing reached Finland. (Years later Finnish aviation authorities investigated a series of incidents in which airliners mysteriously disappeared from Tampere radar screens while in the same area.)

Meanwhile, at a radar station in Skrunda, now in the independent state of Latvia, Soviet military personnel were also tracking Rust. All foreign aircraft flying into the Soviet Union were required to get a permit and to fly along designated corridors, and Rust's was not an approved flight. As the uniden-

The 1980s deployment of Pershing II intermediate-range nuclear missiles to U.S. military bases in West Germany made both the Soviets and the Europeans jittery.

tified aircraft neared the coastline at around 2:10 p.m. Moscow time (an hour ahead of Helsinki), three missile units were put on alert.

From Helsinki, Rust's flight plan was simple: Turn to a heading of 117 degrees and hold course. As he crossed his first waypoint, the Sillamyae radio beacon near Kohtla-Jarve, on the coast of the now-independent state of Estonia, he climbed to 2,500 feet above sea level, a standard altitude for cross-country flight, which would keep him about 1,000 feet above the ground for the entire route. He trimmed the airplane out and flew straight and level. He also put on his crash helmet. "The whole time I was just sitting in the aircraft, focusing on the dials," says Rust. "It felt like I wasn't really doing it."

Soviet controllers continued to monitor the unidentified airplane's progress. Now that it was well inland, army units in the area were put on high alert and two fighter-interceptors at nearby Tapa air base were scrambled to investigate. Peering through a hole in the low clouds, one of the pilots reported seeing an airplane that looked similar to a Yak-12, a single-engine, high-wing Soviet sports airplane that from a distance looks very similar to a Cessna. The fighter pilot, or his commander on the ground, perhaps thinking the airplane must have had permission to be there, or didn't pose any threat, decided the airplane did not require a closer inspection.

Not long after being seen by the Soviet fighter pilot, Rust descended in order to avoid some low clouds and icing. For a brief period, his blip disappeared from Soviet radar screens. Once the weather cleared, Rust climbed back to 2,500 feet, and an image of the unidentified airplane appeared on the radar screen in a new sector, one whose commander ordered two more fighter-interceptors to investigate.

Now nearly two hours into his flight, Rust says the sun was shining when he saw "a black shadow shooting in the sky and then disappear." A few moments later, from out of a layer of clouds in front of him, an aircraft appeared. "It was coming at me very fast, and dead-on," Rust recalls. "And it went *whoosh!*—right over me.

"I remember how my heart felt, beating very fast," he continues. "This was exactly the moment when you start to ask yourself: *Is this when they shoot you down*?"

Asymmetrical threats? The MiG-23 can carry 4,000 pounds of payload at 1,500 mph. Rust's Cessna 172B carried one teenager 550 miles.

From below and to the left, a Soviet MiG-23 fighter-interceptor pulled up beside him. With nearly three times the wingspan and more than 10 times the weight of Rust's Cessna, the MiG seemed huge. Designed to fly at more than twice the speed of sound, the swing-wing fighter had to be put into full landing configuration—gear and flaps extended, wings swung outward—in order to slow it enough to fly alongside the Cessna. Its nose rode high as it hovered at the edge of a stall.

"I realized because they hadn't shot me down yet that they wanted to check on what I was doing there," Rust says. He kept watching the Soviet airplane, "but there was no sign, no signal from the pilot for me to follow him. Nothing." Soviet investigators later told Rust that the MiG pilot attempted to reach Rust over the radio but there was no response. Only later did Rust realize that the Soviet fighter could only communicate over high-frequency military channels.

After the two pilots had eyed each other for a minute, the Soviet pilot retracted the jet's gear and flaps. The MiG accelerated and peeled away, only to return and draw two long arcs around the Cessna at a distance of about a half-mile. Finally, it disappeared.

From both the registration number painted on the side of the airplane (D-ECJB) and the West German flag

TASS/SOVFOTO

decal on its tail, the MiG-23 crew should have been able to tell that Rust's aircraft was neither a Yak nor Soviet. Marshall Sergei Akhromeyev, chief of staff of all the Soviet armed forces, admitted in a 1990 interview cited in Don Oberdorfer's book *From the Cold War to the New Era* that the fighter pilot's commander either did not believe the pilot's report or did not think it was significant, so the information was never passed up the chain of command.

At 3 p.m., with the weather improving, Rust entered a Soviet air force training zone where seven to 12 aircraft—all with performance characteristics and radar signatures similar to Rust's—were being used in training exercises such as takeoffs and landings.

Rust's altitude probably helped him appear harmless. Had he attempted to evade radar, as many later speculated he did, the Soviets likely would have taken more aggressive action to stop him, but even in that scenario, the Soviets' options for dealing with him were fairly limited. Since the KAL 007 tragedy, strict orders were given that no hostile action be taken against civilian aircraft unless orders originated at the very highest levels of the Soviet military, and at that moment, Defense Minister Sergei Sokolov and other top military commanders were in East Berlin with Gorbachev for a meeting of Warsaw Pact states.

As a security procedure, Soviet radar has aircraft under its control regularly reset their transponder codes at prearranged times. If a pilot failed to make the switch, his airplane's radar signature would look "friendly" one minute and "hostile" the next, after the ground had switched over. On the day of Rust's flight, 3 p.m. was one of those times. As Rust proceeded, a commander looking over the shoulder of a radar operator—apparently thinking Rust's radar return was that of a student pilot who had forgotten to make the transponder switch—ordered the officer to change the Cessna's radar signature to "friendly." "Otherwise we might shoot some of our own," he explained.

By 4 p.m., Rust crossed radar sectors near Lake Seliger, a popular summer retreat near the town of Kushinovo, about 230 miles from Moscow. As the radar return for the Cessna popped up on a new set of radar screens, controllers once again took note of the unidentified aircraft. Once again a pair of fighter-interceptors was launched to investigate, but according to a Russian report on Rust's flight, commanders considered it too dangerous for the airplanes to descend through the low cloud deck, so visual contact was never made. Rust was now a little more than two and a half hours away from his destination.

About 40 miles west of the city of Torzhok, another radar controller saw the signal for Rust's airplane and assumed it was one of two helicopters that had been performing search-and-rescue operations nearby. On his radar screen, he flagged it as such, and once again Rust's airplane was marked as a "friendly."

Rust flew on, leaving the Leningrad military district and entering that of Moscow. In the handoff report, the Leningrad commander related to his Moscow counterpart that his controllers had been tracking a Soviet airplane flying without its transponder turned on. But the report said nothing about tracking an unidentified airplane from the Gulf of Finland, nothing about fighter-interceptors intercepting a West German aircraft, and nothing about an unidentified aircraft on a steady course to Moscow. As such, the report set off no alarms.

For Rust, the flight was going flawlessly. He had no problem identifying the landmarks he had chosen as waypoints, and he was confident that his goal was within reach. "I had a sense of peace," he says. "Everything was calm and in order." He passed the outermost belt of Moscow's vaunted "Ring of Steel," an elaborate network of antiaircraft defenses that since the 1950s had been built up as a response to the threat of U.S. bombers. The rings of missile placements circled the city at distances of about 10, 25, and 45 nautical miles, but were not designed to fend off a single, slow-flying Cessna.

At just after 6 p.m., Rust reached the outskirts of Moscow. The city's airspace was restricted, with all overflights—both military and civilian—prohibited. At about this time, Soviet investigators would later tell Rust, radar controllers realized something was terribly wrong, but it was too late for them to act.

As Rust made his way over the city, he removed his helmet and began to search for Red Square. Unlike many western cities, Moscow has no skyline of glittering office towers that Rust could see and head for. Unsure where to go, Rust headed from building to building. "As I maneuvered around, I sort of narrowed in on the core of the city," he says. Then he saw it: the distinctive turreted wall surrounding the Kremlin. Turning toward it, Rust began to descend and look for a place to land.

"At first, I thought maybe I should land inside the Kremlin wall, but then

"I REALIZED BECAUSE THEY HADN'T SHOT ME DOWN YET THAT THEY WANTED TO CHECK ON WHAT I WAS DOING THERE," RUST SAYS. "BUT THERE WAS NO SIGN, NO SIGNAL FROM THE MIG PILOT FOR ME TO FOLLOW HIM. NOTHING."

I realized that although there was plenty of space, I wasn't sure what the KGB might do with me," he remembers. "If I landed inside the wall, only a few people would see me, and they could just take me away and deny the whole thing. But if I landed in the square, plenty of people would see me, and the KGB couldn't just arrest me and lie about it. So it was for my own security that I dropped that idea."

As he circled, Rust noticed that between the Kremlin wall and the Hotel Russia, a bridge with a road crossed the Moscow River and led into Red Square. The bridge was about six lanes wide and traffic was light. The only obstacles were wires strung over each end of the bridge and at its middle. Rust figured there was enough space to come in over the first set of wires, drop down, land, and then taxi under the other wires and into the square.

Rust came in steeply, with full flaps, his engine idling. As planned, he came in over the first set of wires, dropped down, and flared for landing. As he rolled out under the middle set of wires, Rust noticed an old Volga automobile in front of him. "I moved to the left to pass him," Rust says, "and as I did I looked and saw this old man with this look on his face like he could not believe what he was seeing. I just hoped he wouldn't panic and lose control of the car and hit me."

Rust passed under the last set of wires and rolled onto the square. Slowing, he looked for a place to park. He wanted to pull the airplane into the middle of the square, in front of Lenin's tomb. But surrounding St. Basil's Cathedral was a small fence with a chain strung across it that blocked his way. Rust pulled up in front of the church.

He shut down the engine, then closed his eyes for a moment and sucked in a deep breath. "I remember this great feeling of relief, like I had gotten this big load off my back." He looked at the Kremlin clock tower. It was 6:43 p.m., almost five and a half hours since he'd left Helsinki.

He got out of the Cessna. Expecting to be stormed by hordes of troops and KGB agents, Rust leaned against the aircraft and waited. The people in Red Square seemed nervous or stunned, not sure what was going on. Some thought Rust's airplane might be Gorbachev's private aircraft, or that it was all part of a movie production. But once the crowd realized that Rust and the Cessna were foreign—and that he'd just pulled off one of the most sensational exploits they had ever witnessed—they drew closer.

"A big crowd had formed around me," Rust says. "People were smiling and coming up to shake my hand or ask for autographs. There was a young Russian guy who spoke English. He asked me where I came from. I told him I came from the West and wanted to talk to Gorbachev to deliver this peace message that would [help Gorbachev] convince everybody in the West that he had a new approach."

The atmosphere was festive. One woman gave him a piece of bread as a sign of friendship. According to Rust, an army cadet told him that "he admired my initiative, but that I should have applied for a visa and made an appointment with Gorbachev—but he agreed that they most likely would not have let me."

RUST DID NOT NOTICE KGB AGENTS WERE MOVING THROUGH THE CROWD, INTERVIEWING PEOPLE AND CONFISCATING CAMERAS AND NOTEBOOKS.

Rust did not notice that KGB agents were moving through the crowd, interviewing people and confiscating cameras and notebooks. More than an hour after the landing, two truckloads of armed soldiers arrived and roughly shoved the crowd away. They also put up barriers around the airplane.

Three men emerged from a black sedan and introduced themselves. The youngest, an interpreter, politely asked for Rust's passport and whether he was carrying any weapons. They then asked to inspect the aircraft. After a few more questions, they asked Rust to get into the car. The mood, Rust says, was still very friendly, almost mirthful. The Cessna was hauled to Moscow's Sheremetyevo International Airport and disassembled for inspection. Rust was taken to Lefortovo prison, a notorious complex the KGB used to hold political prisoners.

Given the level of planning put into the flight, as well as the number of obstacles that had apparently been overcome, the Soviets could not believe that this was the work of one man, much less an idealistic boy. Investigators believed Rust's journey was part of a much larger plot. Take the date itself, May 28. It was Border Guards Day. Many speculated Rust chose that day thinking the border would be more lightly defended, or perhaps to maximize the embarrassment the flight would cause the military. "I didn't know about it," Rust says. "I said, 'I'm a West German. How should I know about your holidays?' It was just a lucky circumstance." His interrogators also accused him of obtaining maps from the CIA or the German military, but when the Soviet consul general in Hamburg was able to obtain the same maps from a mail order company, as Rust had, the interrogators relented.

Rust's investigators showed him photographs of the bridge he'd landed on. In the photos, many sets of wires stretched across the bridge, each about six feet apart. They asked Rust how he could possibly land with so many wires in his way. Perplexed himself, Rust explained that when he landed he could see only three sets of wires. Upon further investigation, the Soviets learned that the morning of the day Rust landed, a public works crew had removed most of the wires for maintenance; they were replaced the next day. "They said I must have been born with a shirt"—a Russian expression meaning born lucky.

One German periodical published a story saying Rust did the stunt on a bet. Another reported that he did it to impress a girl. Yet another said he did

it in order to drop leaflets seeking to free nonagenarian Rudolf Hess, Hitler's lieutenant, from jail. The Communist newspaper *Pravda* accused Rust of being a patsy in an international plot in which he was supposed to have been shot down and killed in order to provoke an international incident. However ridiculous the rumors were, the Soviets methodically looked into every allegation.

On June 23, 1987, the Soviets completed their investigation. Shortly afterward, prosecutors charged Rust with illegal entry, violation of flight laws, and "malicious hooliganism." Rust pleaded guilty to all but the last charge. There was, he argued, nothing malicious in his intentions.

On September 4, after a three-day trial, a panel of three judges found Rust guilty of all charges and sentenced him to four years at Lefortovo. The prison, though starker and more restrictive than a labor camp, ensured Rust's safety. He spent his time there quietly and was afforded special privileges: He was allowed to work in the garden and receive visits by his parents every two months.

On August 3, 1988, two months after Reagan and Gorbachev agreed to a treaty to eliminate intermediate-range nuclear weapons in Europe, the Supreme Soviet, in what Tass described as a "goodwill gesture," ordered Rust released from prison.

According to William E. Odom, former director of the National Security Agency and author of *The Collapse of the Soviet Military*, Rust's flight damaged the reputation of the vast Soviet military and enabled Gorbachev to remove the staunchest opponents to his reforms. Within days of Rust's landing, the Soviet defense minister and the Soviet air defense chief were sacked. In a matter of weeks, hundreds of other officers were fired or replaced—from the country's most revered war heroes to scores of lesser officers. It was the biggest turnover in the Soviet military command since Stalin's bloody purges of the 1930s.

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The KGB thought Rust might be insane and recommended deportation, but Gorbachev ordered a supreme court trial.

More important than the replacement of specific individuals, analyst John Pike says, was the change Rust's flight precipitated in the public's perception of the military. The myth of Soviet military superiority had been punctured, and with it the almost religious reverence the public had held for its armed forces.

For decades, Soviet citizens had been led to believe "the West was poised to destroy them…that if they let their guard down for an instant that they would be obliterated," says Pike. It was this thinking that helped perpetuate the cold war. Rust's flight proved otherwise: The Soviet Union could suffer a breach without being destroyed by external forces. Ultimately, of course, it would be internal forces that would do the job.

The flying club's Cessna changed hands several times (in 1988, it was listed for sale in *Trade-A-Plane*) before ending up with a Japanese developer who intended to make it an attraction at an amusement park. That project went bankrupt and the airplane disappeared.

Rust never piloted an airplane again. In fact, he spent many years trying to distance himself from his famous flight. In 2002 he founded a mediation service designed to "fight violence by providing proper redress," for which he has spent a lot of time in the Middle East, mostly in Palestinian territories, but to help pay the bills Rust also works for a London-based investment firm.

Though frustrated that he never got to meet Gorbachev, he takes satisfaction in having had a small but important impact on relations between the superpowers. Four years after his "mission," the forces that his flight helped to strengthen dissolved the Soviet Union, and the cold war ended.

Not every test flight has a happy ending.

CONFESSIONS *of a*

THE PROGRAM TO DEVELOP AND TEST BURT RUTAN'S SPACESHIPONE (SS1) HAD MANY DIFFERENT DEMANDS, BUT I CAN SAFELY SAY THE ONE THAT MADE THE PILOTS UNIFORMLY UNCOMFORTABLE WAS THE HOUR-LONG WAIT IN SS1 WHILE THE WHITE KNIGHT CARRIER AIRCRAFT DRAGGED IT UP TO RELEASE ALTITUDE. DURING THIS TIME, THERE IS LITTLE TO DO AND THE MIND IS SOMEWHAT FREE TO WANDER.

For me, what first filled the void was a nagging hint of anxiety, which, over the course of the laboring ascent, began to slip down the slope into fear. And there is nothing quite like fear. Its demons will stalk you until they've conjured all kinds of trouble. I know; I lived with it for years while struggling to land the unforgiving A-7 Corsair aboard aircraft carriers at night. There's something much worse than fear, though. That's having your dreams taken away from you. And I know all about that too.

One of Burt's dreams was to put the Tier One program (the code name given to keep the project secret early on) squarely in the national limelight by celebrating the centennial of the Wright brothers' first flight from Kitty Hawk with the first powered flight of SS1 from the Mojave Desert. No matter which coast you were on, December 17, 2003, was to be a glorious day.

For Scaled Composites, the company Burt started in 1982, the flight was the culmination of months of hard work by a small team of dedicated, smart, and seriously focused individuals. I will remain forever awed by the talent that resides within the unassuming facilities that make up Burt's fun factory.

The Tier One program comprised

BILL DEAVER/MOHAVE DESERT NEWS

SPACESHIP PILOT

MIKE MASSEE

Brian Binnie in his own world aboard SS1 (opposite). White Knight and SS1 during an early test flight over California's wind fields (above).

by Brian Binnie

two stages: White Knight, the carrier-launch aircraft, and SS1, the vehicle that would take us to our 100-kilometer (328,000 feet) altitude. The goal of Tier One was to win the $10 million Ansari X-Prize by accomplishing two privately funded, manned spaceflights, above 100 kilometers, within 14 days.

In the five weeks preceding the centennial, we had completed two envelope-expansion glide flights in the vehicle and a qualifying ground run of the flight-configured, hybrid rocket motor. Modifications by Burt, along with engineers Jim Tighe and Matt Stinemetze, included enlarged tails and esoteric details like strakes and stall fences. Pilot and engineer Peter Siebold was running what seemed like a 24/7 simulator operation, contributing misery and challenges to the rest of us as we tried to keep up. Finally, rocket motor integration details had been pounded into submission by Scaled engineer John Campbell and the SpaceDev team (which provided critical components for the hybrid rocket motor). It was a stunning exhibition of pure willpower to make it all happen by December 17, so the Christmas holidays could be enjoyed in peace.

By December, we were about as smart as we were going to be without throwing all the various elements together and seeing how they really behaved. Some of the features we were interested in learning more about were the rocket motor ignition at altitude, pilot reaction to the energetic impulse of that motor waking up, the acoustic environment (could you hear the radios?), and the structural environment (would the displays even be readable with the motor vibrations?). Oh, and there were the basics, of course, like performance: Did we have the right stabilizer trim setting to get the vehicle flying around the corner—the transition point from horizontal to near-vertical flight? Not enough trim and you could overspeed it and watch parts start to shed. Too much and you drive the angle of attack into regimes where the handling qualities become suspect. And speaking of handling qualities, there was the whole matter of accelerating to supersonic airspeeds within 10 seconds.

There was considerable uncertainty as to whether we should fly the vehicle conventionally as an airplane first, transitioning to electric trim as the control forces became overwhelming, or go with the trims straight out of the gate. The beauty and excitement of flight test is that it is the sword to the Gordian knot of all these details.

Burt has often been quoted in the press as saying that we've lost the courage to explore new frontiers. Usually there's a reference to NASA not too far away. We need less government, the freedom to follow our dreams, and the courage to exercise that freedom. After 20 years with the Navy, I have an affinity for flag and apple pie, and I love that kind of talk. Burt can challenge anyone in the risk/reward business because his flight test safety record is second to none, and he's achieved it while ferreting out the truth on a remarkably diverse number of aircraft over three decades. You might say Burt, Doug Shane (Scaled's new-business director and chief test pilot), and Mike Melvill (Scaled's general manager and senior test pilot) have collectively put together a safety record to die for.

I was thrilled to have the opportunity to fly that first powered flight on December 17. Some might surmise that pulling it off took nerves of steel and other parts made of brass. I didn't see it that way. Expectations were low; just getting the motor lit would have been considered a success. Plus, any troubles during boost would be chalked up to the difficulty of the task. From a piloting standpoint, it was really a no-lose situation.

So imagine my delight when the motor lit and the little-spaceship-that-could scooted around the corner like a bat out of hell. No matter that I was about half a mile behind it. After 15 seconds the motor shut down and SS1 coasted (upside down!) to a modest apogee of 68,000 feet, where Burt's magic feather system removed any further need for piloting skills. The feather system allows the pilot to literally break the vehicle in half—raising half the wing, both tail booms, and tails to

nearly vertical. This configuration is extremely stable, and allows the ship to reenter the atmosphere safely without pilot input. I call it the "angel's wings," and it's a part of Burt Rutan's genius. All's well that ends well, and that boost had been a blast.

On the glide back down there isn't much to do but enjoy the ride, and I admit to thinking we had set the bar pretty high (so to speak) for the Kitty Hawk boys. Paul G. Allen, our reclusive bazillionaire benefactor, had made a surprise appearance that morning and planned to announce officially to the world his sponsorship of the program. So there was considerable horsepower on the ramp to help celebrate what was shaping up to be a rather fine morning, not to mention several hundred people who had guessed Burt's plans and were camped out at the airfield to watch the show.

MIKE MASSEE

ALAN RADECKI/MOHAVE SERVICES

SS1 is chased by an Extra 300 during its dead-stick glide back to Earth (left). Binnie emerged unscathed from his bumpy desert landing, which was harder on SS1 (below).

The SS1 landing pattern had been a surprising source of trouble for the program. Flying a low-performance glider, without spoilers, to a consistent point on final had taken some experimentation, but we finally had a method that was working well for us. With good airspeed and energy I rolled out "in the groove" and lowered the gear. Mike Melvill, who was now on my wing as low chase, offered early congratulations with a clever "Cleared to land." Up in White Knight, Cory Bird, lead engineer for that vehicle and the one who had released me 15 minutes earlier, was heard to say to pilot Peter Siebold: "Well, that's that." All the pieces of the puzzle had fallen nicely into place, and it looked like the good guys had once again prevailed over the forces of evil and darkness.

That is, until I crashed SpaceShipOne.

A funny thing about people: You can build a hundred bridges, but get a little dirt (okay, a lot) on a plastic spaceship and they won't call you Brian the Bridge Builder. Burt put his best spin on the day's events, but when all was said and done there was no escaping the awful impact of seeing the damage: the torn gear and everywhere the miasma of that dirty desert dust. It was a sore sight, and whoever was responsible clearly lacked that important ingredient, that oh-so-necessary quality in test flight known as the Right Stuff.

It seemed like I missed Christmas that year. I spent the holidays dutifully writing a test report, trying to salvage some meaning from that day's events. I even wandered back into the hangar during those days off, hoping to see proof that somehow my personal nightmare was just a dream. But there it would be, the brave little spaceship with so much promise. Broken. Its sad appearance a slap to the senses.

The day after, on our way to play golf (yes, life must go on), Burt shared an anecdote he'd heard about a golfer who missed a two-foot putt that would have won him the British Open. Decades later, when the golfer was asked if he still thought about that putt, he responded, "Oh, I suppose 10 or 12 minutes may go by when I don't think about it."

This experience was threatening to haunt me the same way. I couldn't believe that after surviving My Youth, Carrier Aviation, Desert Storm, and Rotary Rocket, this landing was going to define me. It was clear that whatever 2004 had in store, it wasn't going to come easy.

By April, Doug Shane and Burt had waded through the Federal Aviation Administration's launch licensing process and Peter flew the next powered flight, which reached 105,000 feet. It went straight and true and the landing was flawless. That flight was a huge morale booster to the members, who had been suffering stirrings of doubt after such a long down time. Next up was Mike, and in May he rocketed up to 210,000 feet. Mike never seems to go anywhere without at least a little excitement, and keeping the vehicle going in the right direction despite having lost the primary flight display was gutsy and full of that enviable flight test quality I had lost.

Next, in June, was the coveted flight that would crown the world's first private astronaut. It was an event that was going to go to either Pete or Mike;

by then, I was settled into my new role as White Knight bus driver. Mike got the nod, and on June 21, 2004, off he went into the history books, if only by the slimmest of margins. The vehicle, which had been stripped down to its leanest fighting weight, just managed to sneak past the 100-kilometer mark by some 400 feet. That was about 0.1 percent over the requirement. Exciting stuff again, and signature Mike by this time in the program.

Next up would be the X-Prize flights, with their $10 million carrot. The foundation required 60 days' notice, and we needed the time and something other than a quick fix for our performance problems. Once again, the propulsion team came to the rescue, finding a way to turn up the wick on our trusty hybrid and giving us the confidence that we could get back up to 100 kilometers—but this time carrying all 600 pounds of required payload. Peter was slated for the first X-Prize flight, or X1, as we called it. However, nagging health issues disrupted that plan, so once again the reins went to our tried-and-true guy, Mike. Mike blasted out of the atmosphere with color and character, this time with all those famous rolls after rocket motor burnout. Twenty-nine, in fact, on the way up and just for good measure, one more on the way down.

OPPOSITE: © ROBERT GALBRAITH/REUTERS/CORBIS; LEFT: DAVID PETERS

Second time's a charm: A perfect touchdown (above) is celebrated by Rutan and Binnie (left).

Over these last couple of months, I had found myself in a new alliance, one that had given me a glimmer of hope. Mike had taken me under his wing when we had gone off together to NASA's Langley center in Virginia in August on a Proteus deployment (Proteus was White Knight's predecessor). Upon returning, we modified the canopy on Mike's Long-EZ airplane (which was designed by Burt) to mimic the field of view in the SS1, and were using it as the SS1 landing trainer. In fact, at Mike's urging, I flew anything I could get my hands on, and when I wasn't flying I was in the simulator. I would drag Peter with me and together we spent hours comparing notes on how to fly the vehicle during boost, particularly in the capricious and unforgiving end game as you're leaving the wispy atmosphere.

But now I ask you: With just one more flight to go to claim the holy grail of flight test, to pass Go and get the $10 million, to ensure the company's future with a brand-new investor, Richard Branson, looking on, and to maintain Scaled's sacred safety record, do you go with the tried and true, or do you toss the keys over to the spaceship crasher? Well, the race isn't always won by the fastest horse, but that's the way you tend to bet. And while I wasn't going to be caught unprepared, I held out little hope of getting that second chance to jump-start my dreams.

Mike's harrowing X1 flight had taken place on a Wednesday, and in true Scaled fashion the lights burned late that night as the team analyzed the roll problem. Incredibly, by the next day, we thought we understood what was going on and how to modify the trajectory to avoid the rolling departure. Burt liked what he heard, and with his penchant for promotional impact, thought that a flight on the following Monday, the 47th anniversary of Sputnik's launch, would be an appropriate capstone to the program. All that was needed now was a pilot.

And at about 4:30 on a Thursday afternoon, I was set free.

So as I was saying, easily the worst part of those flights was the hour-long ride underneath White Knight to altitude. In that time you get to live with who you are. And for me, it was strangely comfortable to be in the company of the fear demons once more. I welcomed them, for their presence meant I had my dreams back and the opportunity to realize them.

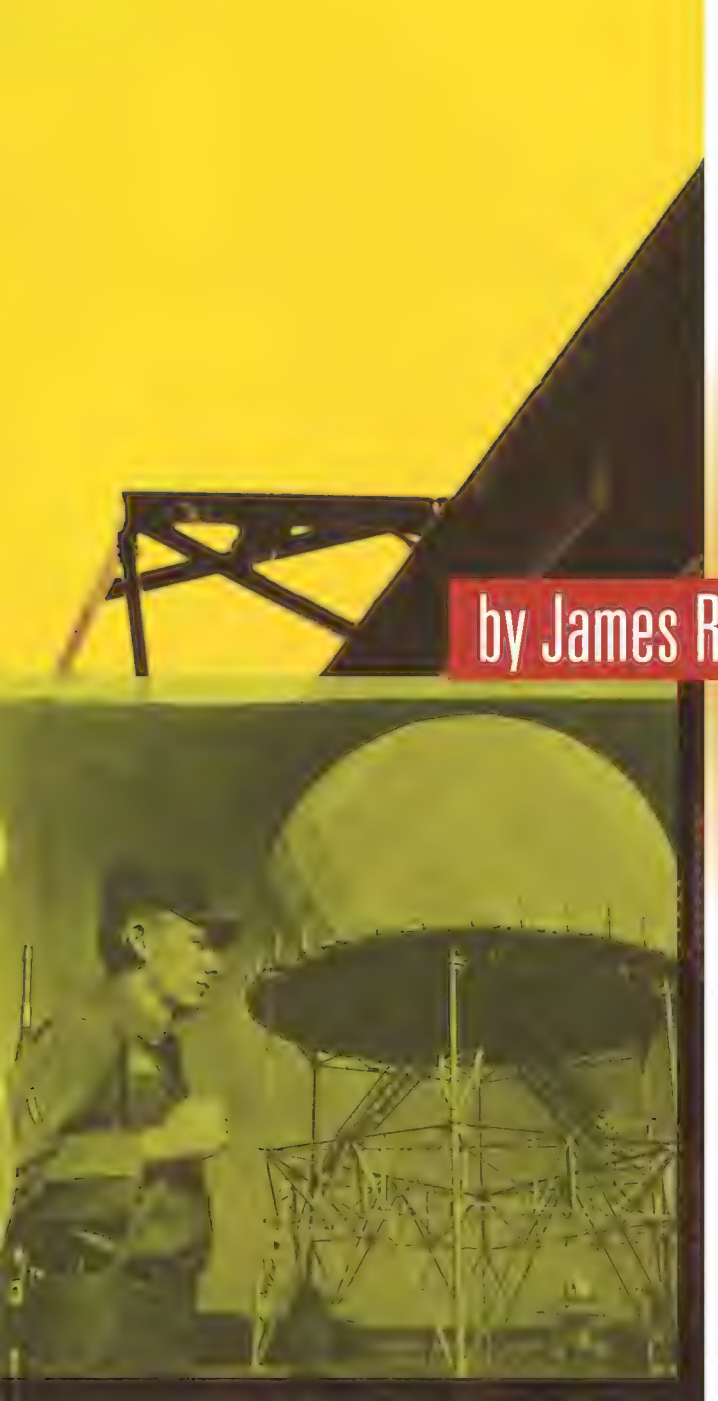
On the glide back down there isn't much to do but enjoy the ride, and I admit to thinking we had set the bar pretty high (so to speak) for the Kitty Hawk boys.

On October 4, 2004, Brian Binnie piloted SS1 to claim the world altitude record previously set by the X-15, and the $10 million Ansari X-Prize for investor Paul Allen and Burt Rutan's Scaled Composites of Mojave, California.

RING OF FIRE

Could Nike missiles have protected U.S. cities from a Soviet attack?

I met Frank Evans last December at LA-96, a decommissioned Nike missile site on Air Force property in Van Nuys, California. Evans had served at missile bases from 1957 to 1969, by which time he held the position of executive officer. Now semi-retired and living in Burbank, he has committed himself to a project that will teach the public about the era of the Nike missiles. For six years, Evans and his Los Angeles Air Defense Museum Association have been restoring another Los Angeles Nike site, LA-43, to its cold war state. Their site needs an elevator platform, and they have obtained permission to remove the one from LA-96.



by James R. Chiles

Evans and I walked from cheery December sunlight down into a dank cavern, illuminated by only a few tiny shafts of light leaking around the elevator platform and by a single floodlight in a far corner. This was the magazine, where the Nike missiles were stored. It was about the size of an elementary school gymnasium and empty except for a few piles of electrical equipment. The east wall was marked with graffiti, but otherwise the chamber was in good order.

With Evans was Scott L'Ecuyer, a fellow cold war veteran, and Master Sergeant Mike Oller, the military liaison detailed to help Evans' group remove the platform. The three plotted how they could rig a crane to help disengage the platform from four rusty support bars at ground level.

L'Ecuyer told me that the Cold War Veterans' Association hopes to carry out a similar restoration at a Nike base in Lorton, Virginia. Still more restoration efforts are planned or under way at sites in Sandy Hook, New Jersey; Fort Tilden, New York; the Florida Everglades; and near Porter, Indiana.

Later, Evans led me along hilltop paths to a concrete pad a little more than three miles from LA-96's launcher complex, overlooking the San Fernando Valley to the north. This spot was once inside the site's fenced radar complex. Evans pointed out the locations of two other Nike batteries, nestled in the mountains on the horizon. During the cold war, Nike batteries

The first U.S. guided anti-aircraft missile, the Nike Ajax (opposite) was developed to defend cold war America. The Army made sure the missiles themselves were protected; at left, a soldier keeps watch near a radar installation on a Nike site at Huntsville, Alabama's Redstone Arsenal.

OPPOSITE: NASM (SI NEG. #9A-02923); INSET: US ARMY REDSTONE ARSENAL

NASM (SI NEG. #9A02935)

Crews stage a readiness drill in Chicago in 1959. This Nike is a Hercules, designed to carry a nuclear warhead.

were arrayed around cities, industrial centers, and bomber bases thought to need anti-aircraft defense. In the 1950s, the Los Angeles area was the major hub of the U.S. aerospace industry, so it ranked high on the list of U.S. cities thought to be vulnerable to an attack by Soviet bombers; at one point, the city was ringed by 16 Nike batteries. New York had 20, and the Navy's harbor facilities at Hampton Roads, Virginia, had eight. Even Midwest cities like St. Louis and Omaha had Nikes.

Over the course of 25 years, the United States and its allies built at least 340 Nike sites around the world; 145 were built in the United States. Most amounted to tiny military bases, complete with mess hall, barracks, recreational facilities, a PX, and a barber shop.

The United States' investment in anti-aircraft systems was immense. Nike system equipment alone cost close to $2 billion; by one estimate, through 1965 the military air defense network, of which the Nike was a critical part, cost more than $50 billion.

Though the Nazis experimented with the concept, the Nike was the world's first operational guided surface-to-air missile, or SAM. Lieutenant Jake Schaefer of the U.S. Army began pondering anti-aircraft missiles in 1944, and the following February convinced the Army to start developing them. Schaefer's original plan, based upon simple, mass-produced, high-speed anti-aircraft missiles directed by ground radar and computers, set the course for the entire Nike era. An Army colonel by the name of Gervais Trichel loved classical literature and suggested renaming the Army's new "Anti-Aircraft Guided Missile" after the Greek winged goddess of victory.

The threat of Soviet atomic bombers streaming over the Arctic to reduce the United States to rubble began to seem a lot more realistic. Beginning in 1954, the Army mobilized 14,000 of the first-generation Nike, the Ajax.

Initially, little happened to boost the Nike's prospects. According to an article in a 1949 issue of *Aviation Week* magazine, Navy experts doubted that Soviet bombers had enough range to make it to the United States. But such confidence soon started to fade. That year, the Soviets successfully tested an atomic bomb, and Soviet premier Joseph Stalin demanded that designers provide him a bomber with a 10,000-mile range, sufficient for an attack on the continental United States. The following June, Communist forces invaded South Korea. Soviet espionage agents were discovered working on a list of U.S. targets to bomb and probing North American air defenses. Civil defense planners estimated that two A-bombs carefully aimed at the Chicago-Gary area would take out a third of U.S. steel production. The threat of Soviet atomic bombers streaming over the Arctic to reduce the United States to rubble began to seem a lot more realistic, and defense spending took off.

Military planners envisioned the Nike as part of an array of defenses. If a flight of enemy bombers were to come in over the North Pole, it would show up first on a North American web of long-range search radar, extending north into the Arctic Ocean via ships and airplanes. This radar was constantly feeding information to a national air defense system, from which the data would pass to Army air defense command posts (AADCPs), located in each Nike-defended city or area. Presumably, Air Force interceptor aircraft, such as the Convair F-102 Delta Dagger, would knock down most of the bombers as they flew toward their target; the AADCP in Los Angeles would mark any surviving bomber formations on its radar screens and assign them to various batteries. Meanwhile, crewmen at the alerted sites would rush Nike missiles to the surface for launch.

A Nike would take off almost as if shot out of a cannon, hitting a speed of 1,700 mph in less than four seconds. Then it would drop its first-stage mo-

NASM (SI NEG. #9A02933)

One former radar officer recalls his Alaska Nike site having "the biggest, meanest dogs I ever saw in my life. If told to attack, they would not stop until the person was dead."

tor and follow guidance instructions transmitted to it from its home base.

To carry out its mission, the Nike needed three sets of radar. All three installations were large and located at the base. First, an acquisition radar swept the horizon, looking for a potential enemy. If one was detected, the target-tracking radar sent up a spotlight beam to lock on to the target. A third set, the missile-tracking radar, kept in constant touch with the Nike. The radar data was fed to the base's computer, which would make the necessary calculations, then send up radio signals that would steer the missile to the target's immediate vicinity. Once there, a command would detonate the Nike's warhead.

Beginning in 1954, the Army mobilized 14,000 of the first-generation model, the Nike Ajax, made by the Douglas Aircraft Company. Each had about the same dimensions as a telephone pole. Bases went up in Missouri pastures, on hilltops in Alaska, and next to high-rise apartment buildings in Chicago.

Despite broad public support for national defense, "not in my back yard" resistance to various sites sprang up. One reason was fear of the Nike booster. Three seconds after each launch, the steel case of the solid-fuel booster fell free, usually crashing to earth a mile or two from the launch site. Cast-off boosters never did kill any Americans, but in time Nikes were involved in two well-reported mishaps. In April 1955, a Nike was accidentally launched from a battery at Fort Meade, Maryland; the missile broke up at low altitude, and the fragments fell onto the Baltimore-Washington Expressway, but no one was injured. And in May 1958, while ordnance personnel and soldiers were installing new arming mechanisms in the missiles at a battery near Middletown, New Jersey, eight Nikes exploded or burned on the ground; 10 men were killed and three were injured.

Other objections to the sites were raised, most centering on the property that had to be sacrificed for the batteries. In Cleveland and Chicago, city officials objected to having to give up park land. In central Chicago, the Army planned to put a Nike base on Wooded Island in Lake Michigan, which, unbeknownst to the planners, was where hundreds of suitors had proposed marriage. And in laying out its first batteries around Los Angeles, the Army penciled in one near the city's international airport, with the radar complex planted on the centerline of one runway's instrument approach. Assuming that future execution of the airport's master plan would extend that runway, airliners on approach could be clearing the Nike radar antennas by as little as 20 feet. Mayor Norris Poulson claimed that the Army would be threatening the lives of millions of people who used the airport yearly. The Army changed its plans, and within two years the mayor was on the Nike's side. After watching a live test firing of a Nike, he told reporters, "I would like to have the Russians see this. Then maybe they would quit their bluffing."

Despite such civilian accounts, insiders knew that staging a launch was no easy matter. "Ajax was a cute little missile but it was a pain in the butt to fuel," says Rod Van Ausdall, a master sergeant at Nike batteries in Texas and Germany. The fueling crew had to wear protective clothing from head to toe when handling a dangerous oxidizer called red fuming nitric acid. "Imagine being in Texas, with the temperature 120 degrees in the shade, wearing a full rubber suit," Van Ausdall says.

NASM (SI NEG. #9A02925)

Fueling the Nike Ajax required crews to don clothing to protect them from an oxidizer called red fuming nitric acid, a chemical that is nasty enough to cause emphysema, pulmonary edema, circulatory collapse, and a miserable death.

From tests it conducted, the Army realized that if Soviet bombers approached in a tight formation, the guidance radar back at the battery could not track the multitude of identical signals and was likely to send the Ajax missile between airplanes, where its fragmentation warhead would explode without effect.

A nuclear blast, on the other hand, could destroy all the bombers in a tight formation—every airplane within miles, in fact. But a nuke capable of such damage would be too heavy for the Ajax to carry. So even before that model had been fully deployed throughout the United States, the Army commissioned a greater-capacity successor, later called the Nike Hercules. When perfected, the Hercules used a safer solid fuel for propulsion, and its range was four times greater than the Ajax's. The Army therefore could protect the same number of cities with fewer missile bases. After the June 1958 rollout of the Douglas-built Hercules, Ajax bases either underwent conversion to accommodate the new model or just closed down.

Everything about the Nike Hercules' nuclear warheads was strictly off-limits. The launcher areas were secured by "shoot to kill" borders.

The debut of the nuclear-warhead-carrying Hercules ended the more relaxed atmosphere typical of a Nike Ajax base. Ajax bases in populated areas had been hosting tours for Boy Scouts, Chambers of Commerce, and anyone else interested, but with the magazines now holding nuclear weapons capable of up to 40-kiloton explosions, show-and-tell seemed inadvisable. One base came up with a more limited tour in which the crew brought up a single unarmed Hercules missile on the elevator platform, allowing onlookers to see it from behind a fence.

Essentially everything about the Hercules' nuclear warheads was strictly classified and off-limits. Troops couldn't acknowledge whether any such weapons were even present on the bases. The Nike sites' launcher areas were secured by "shoot to kill" borders. Attack dogs, loyal to no one but their handlers, patrolled the zone.

Practicing at a New York City Nike site, one crewman (standing) plots an aircraft's approach on a chart, while the other two watch a radar scope to track the aircraft and the missile sent after it.

NASM (SI NEG. #7B22819)

Crews drilled regularly to prepare for a launch, but no Nike was ever sent after an enemy aircraft.

In a February 1961 episode of the television show "Lassie," the collie helps train a cowardly dog to serve at a Nike site, but the reality was far grimmer. "Those guard dogs, they'd kill you," says Dale Nichols, an acting battery commander at KC-60, near Gardner, Kansas. "They'd even tear each other up."

The introduction of the Nike Hercules also revived a feud between the Army and the Air Force over whose anti-aircraft missile was better. In May 1959, the Air Force leaked to the news media a report that during an air defense exercise the previous fall, a Nike Hercules had been able to "shoot down" only one of 12 attacking bombers. And the September 1, 1958 edition of the *Chicago Sun-Times* reported on a secret Air Force study claiming that Chicago could be better defended by scrapping the city's 21 Nike Hercules bases,

AP/WIDE WORLD PHOTOS

because the missile "cannot cope with Russia's fast new bombers." Instead, the Air Force proposed relying on just three bases housing the Nike's Air Force rival: the Bomarc. It was a brash claim; the Bomarc self-guided cruise missile was to be powered by ramjets rather than rocket engines, and that technology was still causing problems.

The feud dated back to the introduction of the Nike. To the Air Force, guided missiles were creatures of the air and so fell under USAF jurisdiction. In the Army's view, shooting at enemy aircraft from the ground was obviously related to artillery and battlefield protection, and thus was an Army job. The Army may have helped stoke the fire; in December 1955 it gave the *New York Times* a report that a Nike had shot down an Air Force Matador missile during a test over the White Sands missile range in New Mexico. A year later the Air Force countered by leaking staff reports that claimed the Nike was "completely unsuitable" for air defense. Even the U.S.S.R. entered the debate. The May 1957 issue of the aviation journal *Sovietskaya Aviatsia* sided with the Air Force, declaring: "As it now ex-

NASM (SI NEG. #95-8691)

An aerial view shows the launchers (at right) at the Nike site at San Francisco's Fort Winfield Scott.

ists, the highly praised Nike system is far from perfect."

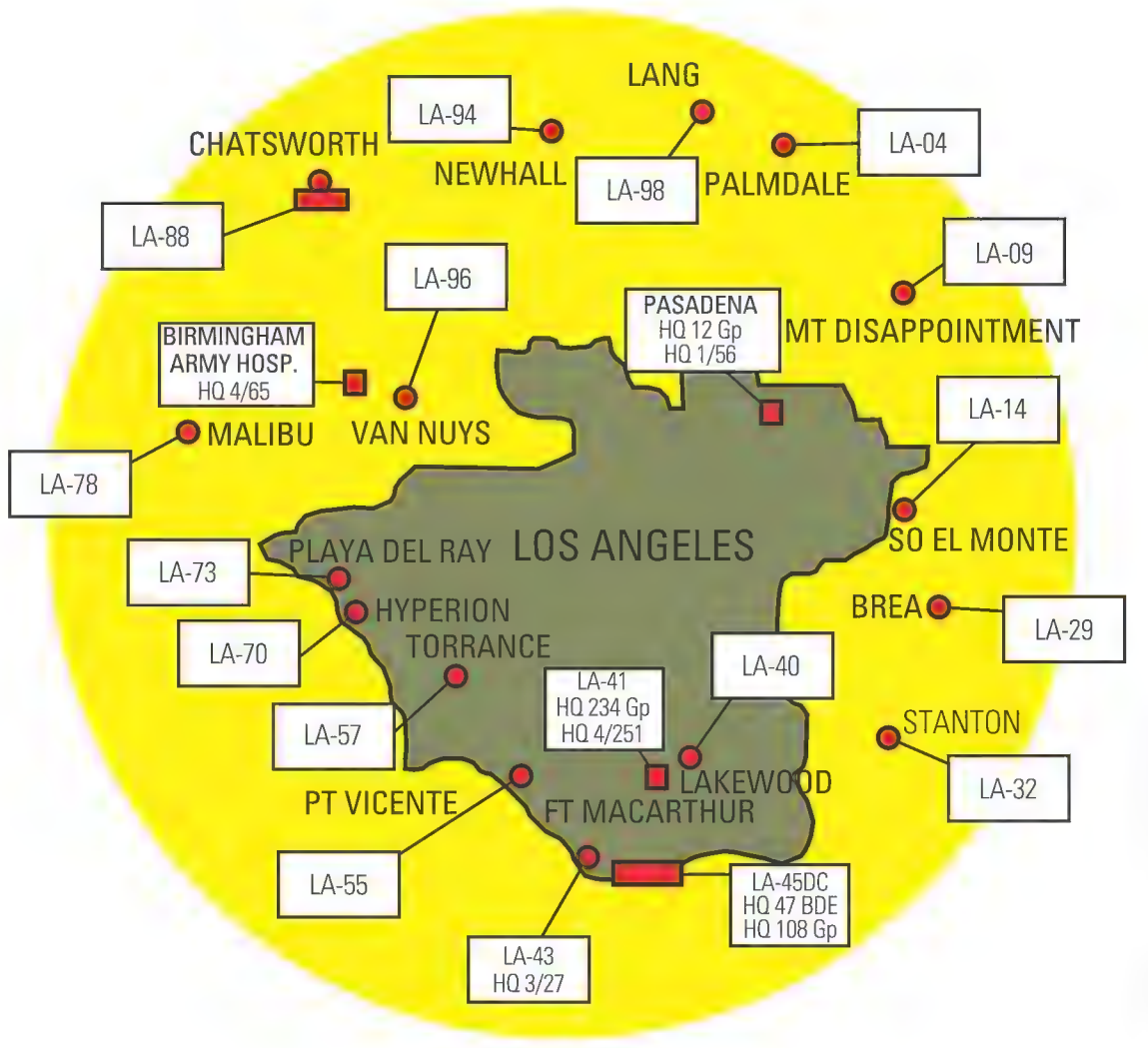
The debate opened to public view some of the difficulties that any SAM was going to face should war come. The Soviets might well field a host of countermeasures: unmanned decoy aircraft, intense radar jamming, electromagnetic-pulse weapons, nuclear weapons trying to blast a corridor through a city's rings of defenses, and widely dispersed bombers using low-level evasive tactics as they approached their targets.

So the Army drilled Nike crewmen again and again in hopes that they and their missiles would rise to the occasion. It threw simulated crises at them, such as a cutoff of communications between a battery and its AADCP. Air Force bombers did their best to jam the Nike's target-tracking radar. The Army sent evaluation teams to show up at the front gate of Nike bases in the middle of the night. The team would trigger an alert, take

Los Angeles Defense – January 1961

Circles: Nike sites that defended the aerospace manufacturing infrastructure in the L.A. area.

Boxes/rectangles: Supporting structures without magazines, missiles, or launchers.



SOURCE: "RINGS OF SUPERSONIC STEEL"

up positions in the launcher and radar complexes, and, as the the battery crew members readied for launch, note every step they took—even their exact words.

All Nike units sent crew members for annual practice at missile-firing ranges in New Mexico, where they worked on tracking and firing at drone aircraft. To keep their equipment and skills sharp, radar operators at some batteries routinely locked their target-tracking radar on passing airliners. A common exercise was "radar bomb scoring," in which Air Force bombers would fly toward a landmark, such as a smokestack, and simulate an attempt to bomb it. Nike batteries would score the bombing runs for accuracy, as well as simulate attempts to shoot the bombers down before they reached the bomb-release point.

In the event of a real attack, the Nike rules of engagement allowed officers considerable freedom of action. According to Dale Nichols, a commander could fire missiles without additional authorization from the AADCP if he saw evidence of hostile nuclear explosions, if the base was under direct attack, or if the radar track of an unidentified airplane showed that it met something called the "pop-up criteria." "That means you exceed Mach 2 and you climb from 2,000 feet to 15,000 feet in less than three minutes," Nichols says. Flying like that would indicate that an attacking aircraft had managed to slip under the radar screen and was about to loft a nuclear bomb toward the target, then make a climbing turn and flee. "Shooting under those conditions was entirely possible," says Nichols, "but only if the missiles were up at the time, and they hardly ever were"; normally, they were kept in the underground magazine.

If a Hercules was launched, the fervent hope was that radiation from its blast would destroy all bombs that were released from the wreckage of an enemy aircraft. Any fireballs created by the Nike warhead's explosion were supposed to occur tens of thousands of feet up. "You didn't want to have the fireball touch the ground," says Frank Evans; such contact might create a mushroom cloud of radioactive fallout. "But there might be decisions to make, say if you had a lot of Russian bombers coming in, not just a couple. You might say 'To hell with it' and accept some fallout. That's if you knew absolutely it was Russians and that they had 25 megatons on board."

If a Hercules had to be launched, the fervent hope was that radiation from its blast would destroy any bombs carried by an enemy's aircraft. Says Frank Evans: "You didn't want the fireball to touch the ground."

Under such extreme circumstances, the awful decision to push a button that would override the "minimum burst altitude" setting and thus trigger a nuclear fireball low enough to scorch American soil would have been the missile commander's alone to make.

Was there any threat that justified the huge amounts of money and manpower the United States spent on the Nike and the even more expensive anti-aircraft defenses of the Air Force?

The Nike's primary mission was to shoot down any Soviet aircraft attempting to overfly the United States. *American Aviation* magazine claimed in 1954 that Soviet diesel-engine bombers were already slipping across the western coastline to plan an attack. While no one ever observed such flights, nine years later the Air Force announced that on March 15, 1963, two Soviet jets—probably recon bombers—passed over portions of Alaska.

According to former Nike radar operator Jose Cuyar, Soviet bombers over the north Atlantic would occasionally "shadow" airliners on their way to New York, attempting to merge with the airliner's radar return and thus testing the ability of U.S. radar and interceptors to detect them. Former radar operator Peter De Marco confirms those observations, adding that the Soviets al-

US ARMY REDSTONE ARSENAL

A different world: For Armed Forces Day in May 1957, the Army proudly exhibited two of its Nikes to the citizens of rocket-friendly Huntsville.

ways broke off before entering the Eastern Air Defense Identification Zone, where they would have been obligated to file flight plans with U.S. air traffic controllers.

By 1962 the Nike reigned as the last-ditch defense of U.S. cities. Though the Air Force's more complex Bomarc cruise missile was finally in production, it was produced in numbers much smaller than had originally been predicted, and at a cost much higher than promised. The system had lost some Congressional support in 1960 after one Bomarc caught fire in its shelter and scattered a small amount of radioactive plutonium at McGuire Air Force Base in New Jersey.

The Nike had evolved into the innermost ring of a nationwide, integrated, computerized air defense system managed by the Air Force. Nike radar equipment was excellent for its time, according to Peter De Marco, who served as an electronic countermeasures specialist, in addition to his radar work. When he got out of the Army in 1969, he went to work for the Federal Aviation Administration, and he was shocked to see how much more primitive the agency's technology was. The controllers there were still tracking radar blips on flat scopes by sliding around plastic "shrimp boats" labeled with aircraft IDs.

Despite the sophistication of its radar, by around 1965, it was clear that the Nike's *raison d'être*—a swarm of enemy atomic bombers—was a threat whose time had passed. Steve Zaloga, author of *The Kremlin's Nuclear Sword*, says that though the Soviets had indeed once entertained schemes to attack and occupy part of Alaska for use as a forward bomber base, "they never went far. By the time it was feasible for bombers to attack [the U.S.], they were doing serious testing of ICBMs." The Army attempted to develop a nuclear-tipped Nike for destroying intercontinental ballistic missiles, but the project succumbed to technical objections, a desire to slash cold war spending, and finally a treaty banning strategic missile defenses.

What proved to be the Nike's downfall was the Vietnam War. As more and more Army money was diverted to that effort, maintenance at the Nike sites began to suffer. "At the end, it was like plugging holes in a dam," Frank Evans says of his unit, PI-93, northwest of Pittsburgh, Pennsylvania. "We let stuff go as long as we could and then we fixed it."

NASM (SI NEG. #95-8695)

Meet the Nikes: Ajax, Hercules, and Zeus (left to right). The Zeus, designed to defend against ballistic missiles, was cancelled in 1963.

Nearly all U.S. Nike bases closed before 1975; Dale Nichols helped shut down his Kansas base. The last operating Nike bases, in Alaska and Florida, closed in 1979. Hundreds of surplus Nike missiles were sold off to allies. Most had spent nearly all their time in their underground bunkers, emerging into sunlight only for maintenance, drills, and alerts. The United States had never launched a single Nike missile against a real or perceived threat. Today, Nikes in good condition are rare beasts, hunted relentlessly by collectors. South Korea still keeps modified Nike Hercules missiles (without the nuclear warheads) on guard near its demilitarized zone.

Most Nike sites have been demolished, at least to the extent that the top slabs of the magazines have been removed and the remaining pits have been filled with rubble from living quarters and other base buildings. Some bases were virtually given away to local governments; Nike Intermediate School is on the site of the base near Gardner, Kansas. Other sites were auctioned off to private buyers. The radar complex for site C-47 in Indiana is used for paintball games, and a relative of mine has one in Kansas City that he uses to store equipment. One buyer converted a launcher complex near Dillsboro, Indiana, to an underground home.

And there are some sites that have been preserved in or restored to their cold war state. One, San Francisco's SF-88, hosts a reunion of Nike personnel every year. Visiting the site summoned vivid memories for Frank Evans. "It all came back—particularly the sounds," he says. "When you walk in, the hydraulic motors sound the same, and there's that sound when the big doors open and come down with a bang."

The site takes pains to give visitors the most realistic Nike site experience possible, even showing the vacuum tubes used in the radar-receiving equipment. On Wednesday through Friday afternoons, SF-88 is open for self-guided tours. On the first Sunday of each month, volunteers hold an open house. On those days, a well-scrubbed Nike Hercules rises from its underground lair and tilts upward on its launcher, as if still ready for the enemy who never showed up.

LEROY'S LAUNCH

Now departing Baikonur…

BY GEORGE C. LARSON

When the alarm goes off at 3 a.m., it's still ink-black outside, and the wind is audible through the window. Turn up the room thermostat to warm the blood, shower, dress, and head down to a brightly lighted dining room. The Sputnik hotel here in Baikonur, in the former Soviet republic of Kazakhstan, is part of Starsem, a Russian-European consortium that provides Soyuz launch services to customers around the world. The hotel is modern, nicely appointed, European in style, and well run.

After breakfast it's time to head to the cosmodrome. This morning Leroy Chiao will launch from there with cosmonaut Salizhan Sharipov to begin Expedition 10 to the International Space Station.

After boarding a big, Euro-style tour bus with huge windows and reclining seats, we leave Baikonur behind and drive through the darkest night there ever was, with no visible landmark, just diamond-hard points of light that could be a hundred miles across the steppe. The bus turns and a different beacon looms: a diesel locomotive's headlight. Time and miles pass. Finally, dark buildings become barely visible in the murk, and we appear to be passing through some vast abandoned facility. The bus pulls into a yard with cars parked every which way. Mercury floods shed a metallic light in bright patches. A sign in Russian reads "Energia," the company that operates Russia's space program. Inside one of these buildings, Leroy has spent hours preparing

ALL PHOTOGRAPHS BY BILL INGALLS/NASA

Leroy Chiao (opposite) rode into space atop Russia's Soyuz, which has launched over 1,700 times, more than any other rocket in the world.

On October 12, 2004, Expedition 10's ride is set upright and checked out on the launch pad.

for the flight, getting into his suit, and readying himself to meet a commission of state officials for a ritual prelaunch interview.

Along for the ride with Chiao and Sharipov, who hails from Kyrgyzstan, is Yuri Shargin, a Russian and relatively recent addition to the cosmonaut corps. He'll go up with the Expedition 10 crew and, while Leroy and Salizhan settle in on the station, come back a few days later with the returning Expedition 9 crew. Rumors circulated that the Russians had sold the Soyuz's third seat to a wealthy civilian but that he was either too big to fit in the capsule, too nervous and jittery, or involved in something shady. Whatever the reason, Shargin got his ticket.

On the bus we are waiting to view the official interview of the Expedition 10 crew. NASA representative Phil Cleary explains that we will be allowed to enter in small groups and that we should head for the left side of the room and make our way as far to the front as we can. It's a mildly tense atmosphere; we have a feeling that we're not terribly welcome here, that we're testing the limits of some rule. We're on Energia's turf and we're way down at the bottom of their list.

About a half-hour goes by as groups of five to seven are dispatched from the bus to disappear through a lighted doorway. Finally the last of us are sent in, and our group is met by a guy in a black leather jacket with a walkie-talkie. He holds up five fingers: Five of us may enter. Then another guy approaches us and holds up three fingers. This happens two or three more times with different guys and different numbers of fingers, but we still haven't moved. Eventually a woman we recognize as one of NASA's Russian staff gestures to us, and we follow her into the building to a room that's jammed with Russian space agency officials, hangers-on, Energia customers, their sisters, their cousins, their aunts.... The mission crew is separated from the crowd by a large glass partition. We squirm between packed bodies to a rear corner of the room, where the crowd thins just enough to allow us to make our way forward along the wall. We can see the partition and hear the amplified voices of the state commission members. And finally, bodies part, and there he is: Leroy, seated to the left of Sharipov. Leroy's smiling, but then it seems as if he's always got a beatific grin. The commission members are wishing the crew a safe journey, and he's nodding in reply.

I first heard of Leroy Chiao in 1989, when *Air & Space/Smithsonian* began developing a story about the selection process that astronaut candidates go through in Houston; the piece, published in the Apr./May 1990 issue, was entitled "The Class of 1990." Leroy Chiao, Ellen Ochoa, and Bernard Harris were among the candidates portrayed, and we soon learned that the three had been among those selected that year to be astronauts. Chiao graciously agreed to give some talks to groups the magazine hosted at the National Air and Space Museum, and as we got to know him, we began to see why NASA had selected him.

He's a chemical engineer with a doctorate from the University of California, Santa Barbara, and an expert in composite materials, besides being fluent in Mandarin and Russian. He worked on advanced materials at the Hexcel

Face time with the spacemen: Dignitaries from the space agencies of two nations offer ceremonial well wishes to Chiao and crew mates. The glass panel protects the crew from germs.

Corporation before moving on to the Lawrence Livermore National Laboratory in California.

When Leroy went shopping for an airplane, he and I exchanged e-mails; he settled on a Grumman American AA-5B Tiger, a 180-horsepower, four-seat, single-engine light plane like one I'd owned. He bought a house in a suburban Houston airport community, where he counted among his neighbors Dave Brown, a fellow astronaut who was later lost on the shuttle *Columbia*, and airshow performer and writer Debbie Gary (see "Along for the Launch," below).

Leroy made his first spaceflight in 1994 on the STS-65 mission aboard *Columbia*; the crew set a record for spaceflight duration: 15 days. STS-72, flown in 1996, provided his first extravehicular activity, or spacewalk; the two EVAs he made on the mission gave him a total time outside of almost 13 hours. But the high point of his astronaut career, he says, was in 2000 on STS-92, when a crew of seven commanded by Brian Duffy installed key elements of the International Space Station, including the Z1 Truss and Pressurized Mating Adapter 3.

Leroy wrote me an e-mail about that mission: "As we drifted away from the station, we watched it, with the Earth in the background. We could see the Z1 Truss with the Ku antenna [for streaming data to the ground] deployed and the PMA underneath. We had installed and connected all of that equipment flawlessly. What a great sense of relief and accomplishment! We were the last crew onboard, before the launch of the first ISS crew, two weeks later. We had left the station in perfect shape, in exactly the configuration that it was supposed to be in, all ready for them."

Leroy had invited me to two previous launches that I couldn't make. Last summer he once again invited me to watch him depart for space, this time from Baikonur cosmodrome, and I thought the third time could be the charm. After I agreed to go, NASA staff in Houston sent me various scary medical advisories about all the diseases, insects, parasites, and fungi that could beset a Westerner in Kazakhstan. But the big worry was the visa.

You need a visa to get into Russia, of course, and NASA was kind enough to handle that exercise. I filled in the paperwork, sent it to a nice lady at the Houston center, and sat back and waited. And waited. Finally, the day before I was supposed to depart, a NASA courier met me in the elevator lobby outside our office suite and handed me the visa with my passport.

We arrived at Moscow's Sheremetyevo Airport in rain. Passengers on Delta's Flight 30 from New York deplaned in lethargic disorder, clutching immigration forms and customs declarations, and slogged for a hundred yards past empty halls until we ended

Along for the Launch

As Leroy, Salizhan, and Yuri walk from the crew bus to their spacecraft, we stand nearby, close enough to see Leroy grin through his bubble-faced helmet. The morning is black and cold, and the rocket is lit up like a tower in a prison yard. We watch them climb the ladder up to a platform at the rocket's side, as if they are going over the wall. We are left behind, intoxicated by the privilege of being here and a little envious of their imminent kick-in-the-pants ride, the stomach jolt of weightlessness, and their god's-eye view of Earth.

I met Leroy Chiao a few years ago, the day I moved into a house across the runway from his in an airpark near Houston. He and a friend came by to welcome me to the neighborhood. He was already slotted for a mission to command the space station and had spent a lot of time training in Russia. It was wonderful there, he said, and he loved the people.

I asked him about survival training in the snowy wilderness. "It's not really wilderness," he said. "The instructors were in a nearby motel, drinking vodka and talking to us on the radio. Everybody drinks vodka over there."

Well, I hate vodka, but when we finished the beer at my house, we walked across the runway for vodka shots at his house. Most of us in the airpark have airplanes, so the usual barriers to friendship slide away like hangar doors opening. We fly together, and when a neighbor launches into space, we come to watch.

When the rocket lifts, I snap pictures and cry, but not because I'm scared that they won't come back. I am simply overwhelmed by the bravery of leaving behind fresh air, open doors, and the freedom to change their minds. The rocket climbs, then disappears, leaving behind a C-shape cloud. We dub it the Chiao cloud and climb back on our bus to celebrate with vodka shots and hearty cheers.

—Debbie Gary

up in a cavern-like grotto, where immigration officers in glass-walled booths would examine our paperwork. It's a humorless process. Russians have had more than their share of terrorism's violence, and the look the officer shot me after peering at my photo stifled any urge to make cheery small talk.

Outside, NASA astronauts Nicole Stott and Kevin Ford, here to escort Leroy's invitees, were waiting in the crowd with a handwritten sign, and they spotted me instantly. (I would learn quickly that Americans stand out starkly here.)

After a few days in Moscow spent adapting to the eight-hour time change, we were joined for the flight to Kazakhstan by a group of high-ranking NASA officials from Houston and Washington led by deputy administrator Fred Gregory. At a security baggage inspection station at the gate, a female inspector X-raying carry-on bags detected a pair of scissors in one and proceeded to ream out its owner in a voice that carried through the whole gate area. These people do not mess around.

A bus pulled up to transport us to a three-engine Tupolev Tu-154 operated by Karat Airlines. The -154 is a 1960s-era airliner resembling a Boeing 727. We clambered aboard and wedged into cramped seats, stuffing carry-ons into any crevice we could find. The old airplane complained mightily on its takeoff run, but once at cruise, the cabin was notably quiet. Soon green Russia gave way to the rusty red soil of Kazakhstan. An hour passed with no sign of civilization below, not even a road. When the airplane started its descent, I checked again and saw a pipeline—there's oil in Kazakhstan.

The airport has one long runway and a small terminal building, and the Tupolev simply turned around at the end of its rollout and taxied back up the runway to parking. No taxiways. But then, there isn't much traffic here either.

At our hotel in Baikonur, various groups made plans to walk downtown to a pizza restaurant. Toward evening, a rumor circulated that Leroy, housed next door, would be down to talk to all of us through a fence separating the two areas. Instead, his flight surgeon approached us whispering apologetically that about 10 minutes ago Leroy put his head on his pillow and seconds later was sleeping like a baby.

The Soyuz TMA manned transport spacecraft got the "A" in its model designation from the word "anthropometric." If you've ever noticed that a lot of the early cosmonauts were on the compact side, it was because the Soyuz cabin is a tight fit. When the joint missions to space were planned, both the U.S. and Russian sides noticed that the Yanks tend toward the XL size. When ISS planners selected the Soyuz as the vehicle for rescuing station crews in an emergency, the Russians had to move stuff around to make room. At the same time, landing velocity was reduced and the custom-fitted seats that cushion the landing impact were made cushier. The rescue Soyuz docked to the station is replaced at regular intervals because its systems gradually deteriorate. Replacements carry crews up, and the old Soyuz vehicles return crews to Earth, along with trash from the station, which burns up in the portion of the spacecraft that is jettisoned on the return flight.

A Kurs radar system provides for automatic docking, but the craft has a system that enables complete manual control, and the crew members spend a lot of time learning how to operate it. The training would pay off for Chiao and Sharipov. The spacecraft is a stack of three modules: the orbital module on top, the descent module beneath it, and the service module—with propellant, instruments, and electronics—at the bottom. Sharipov is commander of the Soyuz, and Leroy would take over as commander once they began the ISS mission. With each crew change, the ISS mission command changes too, alternating between astronauts and cosmonauts.

The booster they'll be riding is a Soyuz FG rocket. Four lateral assemblies, each with a four-nozzle RD-107A engine and propellant tanks, create a flared skirt at the base of the vehicle. These separate laterally and leave a central stage with one engine, which continues to burn. A third stage is built around a four nozzle RD-110 engine. All stages run on kerosene and liquid oxygen, and the four main nozzles on each engine are fixed. Smaller steering nozzles, pointed by hydraulic actuators, direct thrust in order to maintain control. Leroy's Soyuz has been hauled like freight to its launch pad on a railroad car in an unceremonious crawl and now stands upright just a few miles from here, awaiting fueling.

After the mob scene with the commission, the crew is scheduled to walk out to a bus and head for the launch pad. It is said that on his way to the launch that made him the first man to fly in space, Yuri Gagarin stopped to relieve himself, so it has become traditional for all crews to follow suit. Our own bus, too far behind on the bumpy road to the pad for us to wit-

Chiao assumes the launch position for a pressure check of his spacesuit.

ness the traditional pause in transit, eventually lurches into a densely packed unpaved parking lot.

Above us, dozens of spotlight arrays bathe the rocket in brilliant white. Incandescent light bulbs on the scaffold around the rocket glow like amber gems, lending the scene the ambiance of an amusement park. As the crew members step off the bus, officials swarm them, wishing them well and patting them on the butt the way athletes do. The riotous and energetic celebration could not be more different from the relatively sterile atmosphere on the pad at Florida's Kennedy Space Center before a shuttle launch.

The first light of day reveals high clouds and good weather for the launch, which is scheduled for 9:06 a.m. Because the Soyuz capsule does not have the steering capacity of the shuttle, it must be launched at a precise time in order to rendezvous with the space station. With about a half-hour before liftoff, we clamber aboard the bus again and head out to the observation site, which is surprisingly close to the slim little Soyuz, perhaps half a mile away.

The Russian words coming over a loudspeaker are indecipherable to me as the crowd spills over and around the viewing site, finding perches everywhere among the bleachers. Then, as the voice on the loudspeaker counts down in Russian, we see a flicker of light at the pad and some smoke as an umbilical swings away from the rocket. The sound takes a couple of seconds to reach us; then the roar turns to a crackle as the engines come up to full thrust, which takes a few more seconds. The hold-downs release and the Soyuz rises on a flame as bright as the sun. A plume of translucent light, blue and orange, like a huge veil as long as the rocket is tall, flickers and dances beneath the brilliant white hot spot. This really is the sports car of space vehicles. *Look how fast it's accelerating*, I'm thinking; I have to force myself to remember that Leroy is aboard this thing, which is now, after maybe a minute, way up there, just a dot. He's on his way, and the track begins to arc away from us. People are hooting and cheering, and then I can't see a rocket anymore; I can only hear it and see its trail of white vapor.

The Soyuz lifts off on October 14, 2004, bound for the space station.

Two days later we arrived in early morning darkness at the mission control center in the village of Korolev. In the control room a handful of technicians presided over banks of computers, and on one of the screens, we could make out the blurry image of the station getting closer. It's hard to say exactly when we began to sense that something wasn't right. Although there was never any excitement in the control room, we gradually became aware that the station seemed to be getting closer rather quickly. Too quickly.

Then the station receded on the screen. Within minutes, NASA officials reported that the closing velocity had been too high and that Sharipov switched from the automatic docking mode to manual, backed off, and then flew the Soyuz to a successful docking. A week later an Energia official explained that one of the Soyuz's thrusters was functioning at only 30 percent of its rated thrust while, at the same time, a control system that measures acceleration had malfunctioned, together producing the incorrect high closing rate. An alarm had tripped at about 50 yards, he said.

Once the docking was completed, it was only minutes until video from inside the station showed the three Soyuz crew members floating through the open hatch. Leroy would be up there for six months.

DEBRIEF:
HYPER-X

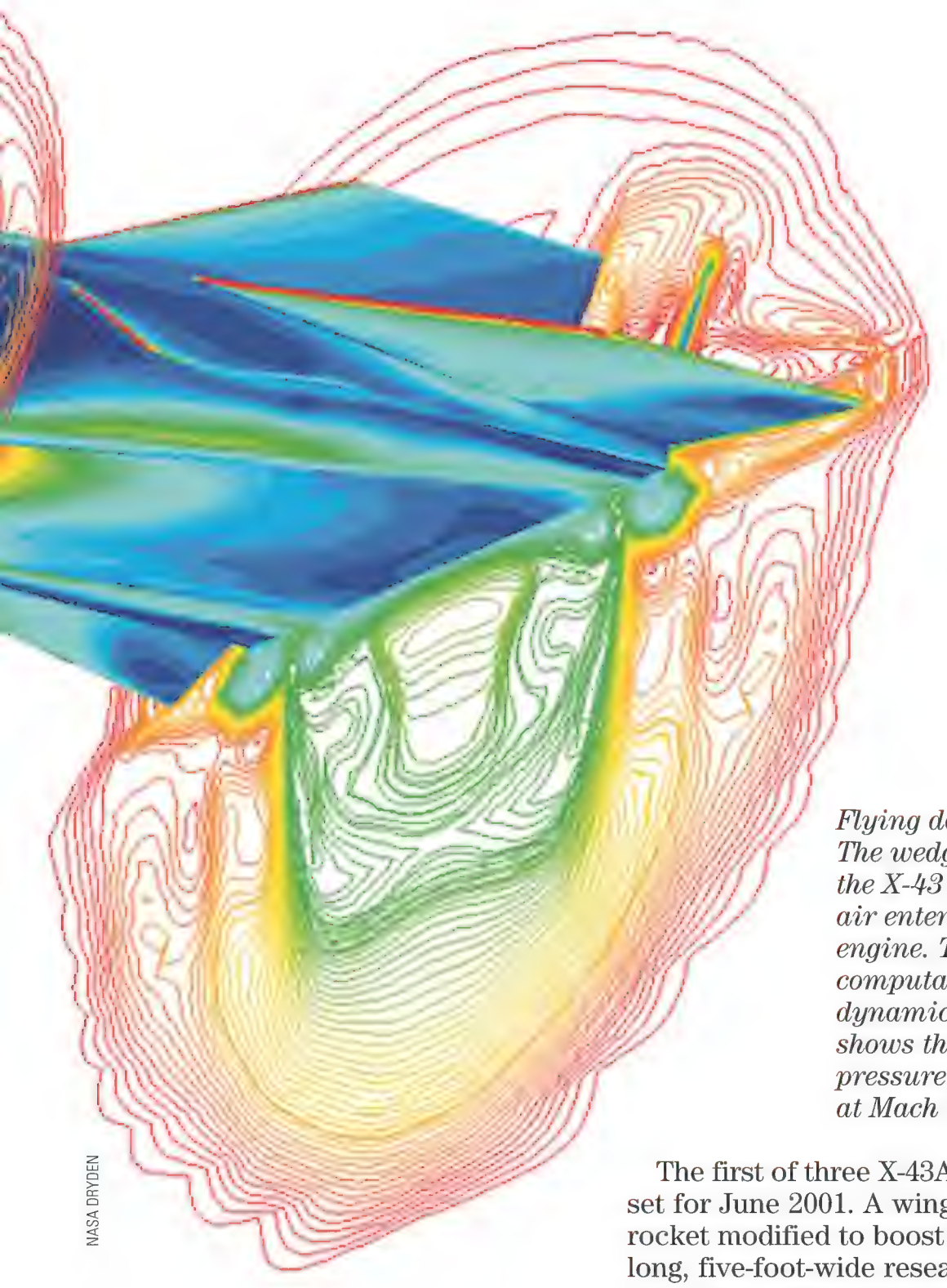
INSIDE THE FASTEST AIR-BREATHER ON THE PLANET.

by Michael Milstein

IT WILL NEVER HANG IN THE Smithsonian, because it ended up on the bottom of the Pacific Ocean. Its pilots will not enjoy ticker tape parades; they were all on the ground, watching the computer-operated craft on video screens. But in about 10 seconds, a combination of scientific persistence and untested technology constructed of leftovers from secret military projects changed how we define "fast." The little black wedge called the X-43A, smaller than a Ferrari, flew faster than any air-breathing airplane ever—nearly 10 times the speed of sound, and at about two miles per second, swift enough to cross the country in 20 minutes. It owes its tremendous speed to a jet engine that has no moving parts; in fact, it seems nothing like an engine, and some scientists doubted it could ever work.

For proponents of the engine known as a scramjet—short for supersonic combustion ramjet—the brief flight offered the same sort of vindication the Wright brothers earned in 1903 at Kitty Hawk: The project rebounded from a catastrophic failure of the first X-43A flight in 2001, when a booster carrying the airplane careened out of control. And the flight finally turned the experimentalists' concept into reality, a result of five decades of research aimed at producing a hypersonic jet engine that could propel airplanes nearly into space and back again more cheaply and safely than rockets.

"It was the Holy Grail, if you will," says Anthony Castrogiovanni, the X-43A propulsion team leader at Alliant Techsystems, the NASA contractor that engineered it. "A successful flight was going to change the way the world thinks about hypersonics."



NASA DRYDEN

Flying doorstop: The wedge shape of the X-43 compresses air entering the engine. This computational fluid dynamics image shows the vehicle's pressure gradients at Mach 7.

There's fast, there's supersonic, and then there's hypersonic—more than five times the speed of sound, a realm rarely probed by airplanes because few can survive it. Scramjets are the only engines other than rockets that can reach hypersonic speeds. Their first use would likely be by military forces, as light and adaptable engines for ultra-fast and maneuverable missiles. But they are such a temperamental blend of speed, flame, and fuel that any vision of passenger-carrying scramjet-powered airliners crisscrossing the skies remains a distant one. "It's a very simple concept that's very complicated to pull off," says Vince Rausch, manager of NASA's Hyper-X program, parent of the X-43A.

The first of three X-43A flights was set for June 2001. A winged Pegasus rocket modified to boost the 12-foot-long, five-foot-wide research craft to its planned altitude and speed dropped like clockwork from the wing of a NASA B-52 mothership over the Pacific Ocean northwest of Los Angeles. After five seconds the Pegasus' solid rocket motor ignited in a blaze. But eight seconds later, as the rocket neared the speed of sound, its right fin tore off, then the left fin, rudder, and wing. The 49-foot rocket tumbled wildly in a smoky blur until a Western Test Range safety officer triggered onboard explosives to destroy it. The X-43A aircraft attached to its nose never had a chance.

For Griff Corpening, an engineer at NASA's Dryden Flight Research Center in California, and others who had shepherded the project for some five years, the failure felt like a kick in the gut. "People look at science and technology as dry stuff, but I wish they could understand all of the rush of emotions that you feel," he says. At least the failure had been the rocket's, not the scramjet's. An investigation determined that the Pegasus rocket was too far out of its element. Orbital Sciences had designed the launch vehicle to be released from an airplane at 40,000 feet and to loft satellites into orbit. But this time it was released 20,000 feet lower, where the air is denser. Computer models based on data from earlier Pegasus flights predicted the craft's fins and rudders could handle the denser air.

The project team members were buoyed by one batch of data, though: The little X-43A held together even as the out-of-control rocket whipped it every which way. "It told us we had one heckuva solid vehicle," says Ted Rothaupt, an engineer at Boeing Phantom Works, Boeing's advanced research and development branch, which helped develop the X-43A. The X-43 looked tough enough for hypersonic flight—if only it could get there.

As long as humans have flown, they have longed to fly faster. Most members of the X-43 team are all about speed. When Paul Reukauf, deputy project manager for the X-43A at Dryden and a pilot himself, heard that fellow scientist Chuck McClinton had bought a boat, he had only one question: "Why would anyone spend that amount of money to go six knots?"

Rockets have always outpaced airplanes. They accelerate by rapidly combining fuel with oxygen they carry on board. The drawbacks are that liquid oxygen is heavy and hard to handle.

Because the oxygen tanks are so weighty and take up so much space,

they reduce the rocket's payload-carrying capacity. And that's one reason why the cost of firing something into space is about $10,000 per pound. Speed is even pricier. The faster a rocket must go, the more fuel and oxygen it needs—in other words, still more tankage. The craft gets heavier and heavier, eventually reaching a point where it simply cannot carry enough fuel and oxygen to go any quicker.

But jet engines can get oxygen from the air. Without oxygen tanks, the craft suddenly gains up to five times more room for payload, it picks up speed, and it costs less to fly. In common jet engines, like the ones on commercial airplanes, rotating blades compress incoming air. Injected fuel mixes with the air and burns. The hot gases turn a turbine to drive a fan and compressor, then expand out the rear nozzle, propelling the airplane.

The trouble with conventional jets is that they have a built-in speed limit. When they approach Mach 4, or four times the speed of sound, the air is arriving faster than they can swallow it. Drag caused by the engine and airplane moving through the air cannot be overcome by the engine's propulsion. And the friction of the air at that speed heats the engine until it begins to melt.

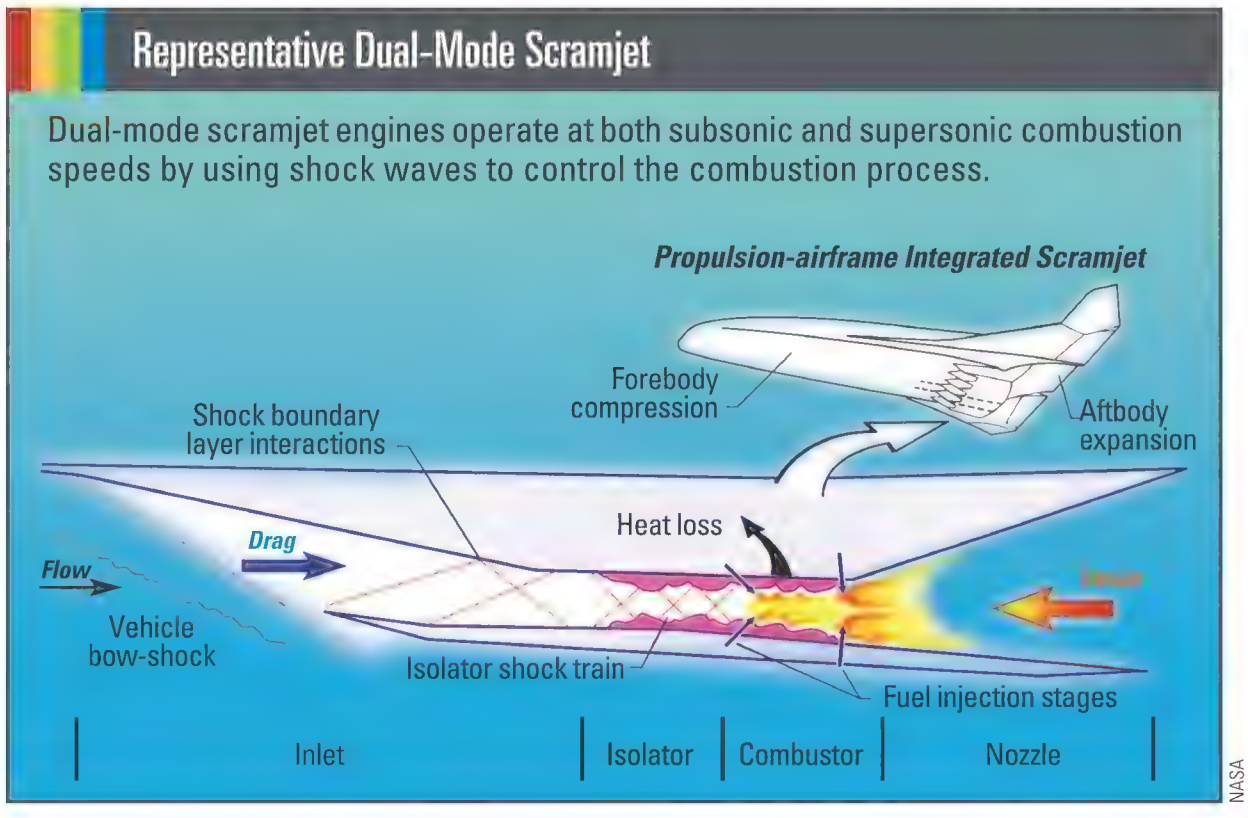
These dilemmas are compounded by the powerful force of shock waves. An airplane flying faster than sound outruns its own sound waves, which then attach like the wake of a boat to the airplane's nose and tail. These wakes are the shock waves bystanders on the ground hear as a *ba-boom*. Closer to the airplane, shock waves are much more intense. NASA learned early on that shock waves can be very fickle—and very dangerous.

A final goal of the X-15, the experimental rocket-powered NASA aircraft that broke speed and altitude records through the 1960s, was to test a new design for a scramjet like the X-43A's. In 1967 engineers at Dryden fitted beneath the X-15 a mock version of the engine to study the aerodynamics at Mach 7. Neither pilot William "Pete" Knight nor anyone else knew it during his flight, but unexpectedly strong shock waves trailing the dummy engine as Knight reached Mach 6.7 interacted with other streams of air and began cutting into the aircraft like a scalpel heated to 3,000 degrees. Explosive bolts meant to jettison the engine prior to landing detonated early, and the jet fell off. Heat ripped into the X-15's underbelly, and instruments started going dead. Knight set down just before the fuselage disintegrated.

Test pilot William Dana, serving as mission controller at the time, saw the X-15 riddled with holes, and "my knees started shaking," he recalls. "It looked like a maniac had gone wild with a cutting torch and had a field day." NASA cancelled further airborne scramjet tests, and that X-15 never flew again. "We fried the airplane so badly we decided it was better done in a wind tunnel," Dana says.

TONY LANDIS/NASA DRYDEN

Like the National Aerospace Plane but one-tenth its size, the X-43 vehicle was so crammed, there wasn't room for a marble.



NASA

The faster a jet goes, the simpler its design must be. To keep heat from building up, the aircraft must have

no parts that slow the air and bounce shock waves around. The solution? Get rid of the compressor blades and other rotating pieces. For hypersonic flight, engineers approached airplane design in a whole new way. Instead of fans mechanically compressing air sent to the tunnel-like engine combustion chamber, the bow of the airplane plows into and compresses air, funneling it into the chamber; here, the airplane body forms part of the engine.

"What you have is a flying engine," says McClinton, technology manager for the Hyper-X. When the supersonic speed of the airplane rams oncoming air into the combustion chamber, the engine is called a ramjet. But that works only at very high speeds. The SR-71 Blackbird, for example, has turbojets with afterburners to accelerate and cruise at supersonic speed. When the aircraft is flying fast enough to compress the air on its own, its engines remake themselves. Ducts direct part of the airstream around the rotating compressors, and the engines become ramjets that propel the airplane to Mach 3 or higher.

But ramjets, like turbojets, slow the air to subsonic speed before combining it with fuel. This minimizes formation of troublesome shock waves, but it works only up to about Mach 6.

The eight-foot high-temperature tunnel at NASA's Langley Research Center can mimic hypersonic conditions for fractions of a second.

NASA DRYDEN

Any faster and the engine begins to melt from the effort to slow all the air down. That's when a scramjet becomes the only option. As the air races through the engine, it is moving at supersonic speeds and generating shock waves. But a scramjet uses the shock waves to advantage.

Picture a river with banks lined with concrete. The banks reflect waves and boat wakes in the water. A scramjet combustion chamber does much the same with shock waves. On the ground, you could peer into it and it would look like an empty pipe. But once moving beyond the speed of sound, its internal design and shape orient shock waves into a precise pattern. It directs, compresses, and focuses the airflow, creating the right temperatures and pressures for combustion. A scramjet fashions the essential components of a jet engine from the air currents racing through it. Joel Sitz, NASA's X-43A project manager at Dryden, shrugs and says: "You're training the air to do tricks."

The X-43A's combustion chamber measures about three feet in length, so at a top speed of 7,000 mph, air whips through it in roughly .001 second. That's not much time for fuel to mix with oxygen, ignite, and burn. Engineers liken the challenge to keeping a match lit in a tornado—but more difficult. If fuel burns too fast, the airflow inside the engine reverses, causing power loss—an "unstart," in jet jargon. If it burns too slowly, it's as if your car's gasoline were igniting a block behind you. All its energy goes to waste.

But in the mad rush of air, the shock waves form a kind of shelter, as you would with your hands to light a candle in the wind. Into the eye of this storm, the X-43A's engine injects hydrogen fuel and ignites it with silane, a silicon gas that instantly burns on contact with air.

For the better part of 50 years, scramjets were more theory than reality. It's impossible to thoroughly test them in laboratory wind tunnels; even the fastest tunnels can produce scramjet airspeeds only in brief pulses. They provided split-second snapshots, but never a moving picture of a scramjet in continuous flight. Some doubted a scramjet could ever produce enough power to overcome the drag of air hitting any airplane at over Mach 7, no matter how sleek and aerodynamic.

But if it could, it would enable production of a jet fast and powerful enough to do much of the hard work of reaching space. Because a scramjet must move at Mach 6 or 7 to ignite, it needs a booster to take off and accelerate, but the rocket could be much smaller. A scramjet-rocket combo could carry the same payload as the space shuttle, but weigh only a quarter as much. That reduction could cut the cost of putting a pound in orbit by perhaps 80 percent, although some engineers say the research cost to develop the scramjet could cancel any gains.

President Ronald Reagan believed. In his 1986 State of the Union speech, he announced "a new Orient Express that could, by the end of the next decade, take off from [Virginia's] Dulles Airport, accelerate up to 25 times the speed of sound, attaining low Earth orbit or flying to Tokyo within two hours." He was invoking the National Aerospace Plane, a NASA outgrowth of a highly classified military project to develop a reusable, scramjet-driven aircraft that could take off from the ground and accelerate into space or travel between continents. Though NASA called it the X-30 and a successor to the space shuttle, it got its billions in funding from the military. Invoking the image of an airplane that could race in and out of

enemy airspace before it could be detected and shot down may have been mostly cold war intimidation, though, because by the 1990s the military lost interest and Reagan's vision never flew.

Instead, it became the X-43A. The razor-like X-43A is the spitting image of the National Aerospace Plane, but less than a tenth the original size. A 1995 NASA competition made it next in the line of experimental X-planes. The details of its engine chamber remain highly guarded by the military—so much so that while it's on the ground, padlocked covers on both ends of the chamber shroud it from anyone without clearance. Its scaled-down size was matched to a mission that was narrowed to focus on one basic goal: Prove a scramjet can power an airplane, and do it quickly and cheaply.

That meant keeping it simple. The X-30 was to have a human crew; the X-43A would be automated. It would fly only as long as it took to burn the hydrogen fuel it could carry. Engineers thought about trying to land it on the Navy's San Nicolas Island, off the coast of California, but gritted their teeth and decided it would be simpler for it to transmit data and ditch in the ocean.

The SR-71 lifts off with a turbojet before accelerating to ramjet mode. The National Aerospace Plane was also intended to shift gears in flight. The X-43A had to rely on a Pegasus rocket to get up to speed.

That raised a question: How do you push the 3,000-pound X-43 off a rocket going thousands of miles an hour? Earlier scramjet experiments in Australia and Russia had attached scramjets to rockets to prove the engine would function at high speeds. They did not try to power an airplane with it. The X-43A had to leave the rocket and fly on its own. Finally engineers found a technology to push the two apart fast enough so that they would not collide: the piston system that B-1 bombers use to eject bombs.

The X-43A was packed to the gills with instruments, fuel lines, and controls. Its budget did not allow for miniaturizing, and its size wouldn't allow for backup systems. Technicians shaved its battery to the hundredths of an inch. "There was no room to drop a marble inside," says Castrogiovanni.

Everything was enclosed within a body that would endure the highest temperatures and pressures an airplane had ever faced. Stainless steel and carbon fibers formed the wings' leading edges, sharpened like razor blades. The aircraft's nose was made from an enormous piece of tungsten to take the heat and balance the heavy back end of the aircraft. Its engine chamber was crafted from copper and cooled by water lines to control temperatures not much lower than those on the surface of the sun. Its fuselage was covered with the same sort of thermal tiles that cover the space shuttle. But instead of crafting each tile to precise dimensions, as NASA does for the shuttle, X-43A designers kept costs down by first cementing the tiles in place and then machining them to a smooth surface.

TONY LANDIS/NASA DRYDEN

TOM TSCHIDA/NASA DRYDEN

Borne aloft by a now-retired B-52 mothership (left), the X-43 test vehicle reached Mach 9.7 after separating from a Pegasus launch vehicle. A piston device used to eject bombs from a B-1's weapons bay enabled the X-43 to separate from the rocket booster, light up its scramjet, and fly independently.

Even the airplane's fins were designed with a small gap so that when they expanded from the heat of high-speed flight, they would not bind with adjacent parts. Designers were careful not to make the gap too large, though, or the airflow would become turbulent and slow the vehicle down.

To avoid another catastrophe, engineers beefed up the Pegasus' fins and rudders and removed 3,300 pounds of the rocket's propellant. By eliminating some fuel, the engineers could launch at the higher, thinner altitudes the rock-

JIM ROSS/NASA DRYDEN

On the first X-43 flight, the Pegasus went out of control, but later flights more than made up for the loss.

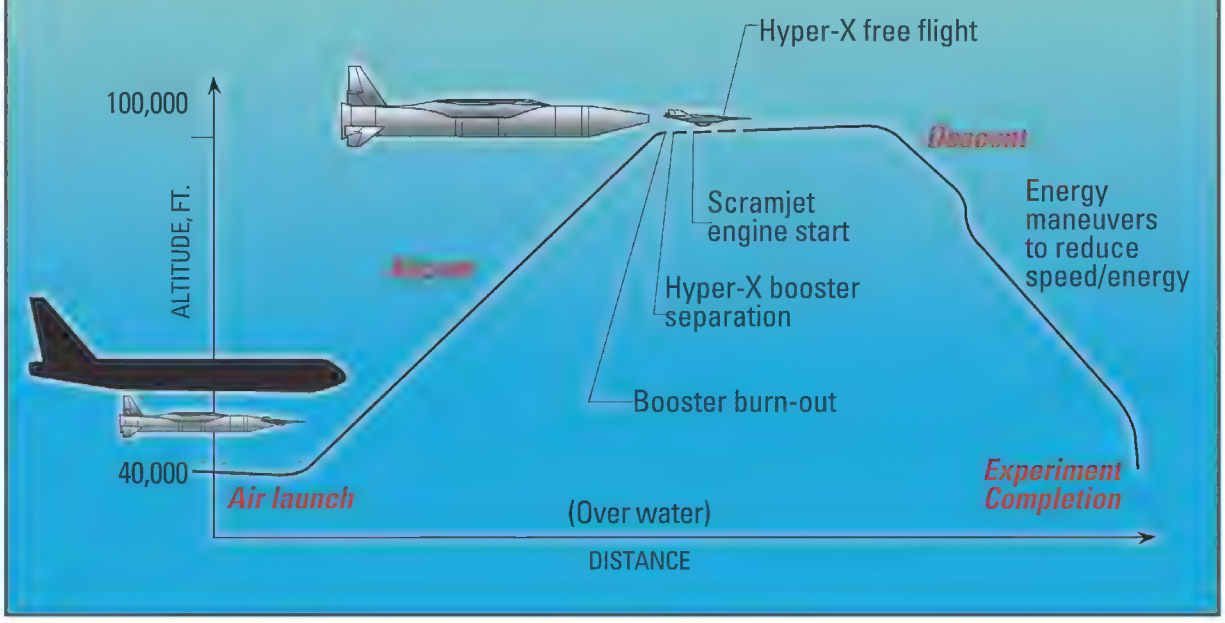
et was designed for without worrying that it would loft the X-43A too high.

On March 27, 2004, the second X-43A took to the sky. This time it stayed on course. When it hit 95,000 feet, the bomb pistons fired with 10,000 pounds of force. The aircraft was finally on its own and flying. Within 2.5 seconds, the engine door opened, the train of shock waves instantaneously lined up inside, the silane ignited the hydrogen, and, for the first time, a scramjet was accelerating on its own. The engine burned for 11 seconds, propelling the X-43 to Mach 6.86. It bested the previous air-breathing speed record—just over Mach 5, set by a ramjet-powered missile—and outdid the airplane speed record, Mach 6.7, set by the X-15.

Eight months later, an X-43A fine-tuned for even higher speeds ran its engine for 10 seconds, shooting to a record-breaking Mach 9.8 on November 16, 2004. About 500 sensors transmitted temperature, pressure, strain, and other readings back to NASA, providing hundreds of times more information than the most elaborate wind tunnel test ever could.

Hyper-X Flight Trajectory

The mothership and a Pegasus booster carried the X-43 to its test altitude, but its scramjet engine took over from there. Each flight ended in the Pacific.



NASA

After its engine stopped, the X-43 coasted through a sequence of maneuvers to reveal more about its aerodynamics. One signal suggested it may have started melting on its way down.

Researchers will be crunching the data for years, but they already know a few things. One is that they have the workings of scramjets well figured out: The X-43A's performance came very close to their predictions. Another is that flying a scramjet for much longer than 10 seconds will demand a far more sophisticated cooling system and revolutionary new materials to handle the intense heat.

The X-43A's fleeting glimpse into the future may also be the last for a long time. NASA has shifted focus to President Bush's moon-Mars exploration initiative, carving aeronautics research down to just five percent of its newest budget. There is now almost no money for hypersonics. Engineers have transferred to other projects, and Chuck McClinton is sending wind tunnel models and other stepping stones in scramjet science to the Smithsonian.

"We're going to be [part of] history," he says. "It's like many technology demonstrations. You've proven it works. Now you're done."

Contractors are lobbying Congress to continue work on the X-43C, a sibling of the original but powered by more easily handled hydrocarbon fuel, and the military continues modest hypersonic research under such programs as the Falcon project, co-sponsored by the Defense Advanced Research Projects Agency and the U.S. Air Force. But without a national effort, it's unlikely to get very far, McClinton says. The scramjet, not quite rocket or jet, may end up retreating to the shadows.

For 10 seconds, though, it was way out in front.

The People and Planes of CREVE COEUR

Swallows have Capistrano. Wacos have Creve Coeur. ✳ by Linda Shiner

"Dan's going to fly *The Question Mark* tomorrow," says Terry Chastain to a small group gathered near his hangar. Heads nod approvingly and a few words of encouragement are directed toward Dan Mueller, who seems slightly uncomfortable—either with the attention or with the thought of flying the airplane. *The Question Mark* has a 500-horsepower modified Wright R975 engine, a lot of engine for a Waco Taperwing. The airplane was built in 1932. The following year, it crashed during a race in Oklahoma City, and its pilot was killed.

At Creve Coeur Airport, everybody knows the little red Waco with the big engine. Everybody knows its caretaker, Terry Chastain, its owner, John Cournoyer (who is also part owner of the airport), and Dan Mueller, the pilot about to be initiated. In small-town Creve Coeur, everybody knows everybody else and what they fly—and how often.

Creve Coeur Airport is on the outskirts of busy, sprawling St. Louis, Missouri, and it's a world away. To drop in for a weekend is to step back to a time when flying was not a way to cross continents but a pastime to enjoy with friends and a chance to raise a little hell. It's not just that the airplanes you see puttering around the airport are almost all classics from the period between the world wars (the airport hosts one of the largest collections of vintage aircraft in the country—more than 75 Monocoupes, Stearmans, Travel Airs, Stinsons, Fairchilds, and rarer types). And it's not just because the setting is so lovely, a checkerboard of fields and farms with two great rivers, the Mississippi and Missouri, converging nearby. Creve Coeur evokes nostalgia because it, like most of the small airports profiled in this series, has found a way to keep the noise of modern life away from the airport grounds—or at least a way to drown it out with the continual cough and hum of Continentals, Lycomings, and the rarer powerplants of an earlier time.

When I visited Creve Coeur last fall, everybody I talked to told me that the chief reason the airport has managed to hang on to its small town quality is Al Stix, who bought the airport with two partners, John Cournoyer and John Mullen, in 1983. The three created enough airplane energy to draw others in, but Stix, a St. Louis businessman, is the social director who keeps them coming. Every Sunday between 50 and 60 people show up at the airport for meals that Stix cooks on giant grills. Stix also hosts an annual Halloween costume party, a Christmas party, and several fly-in parties throughout the year.

The American Waco Club has come to Creve Coeur for its fly-in every year since 1993. "Why would we want to go anywhere else?" says club president Phil Coulson, who flies a Waco UPF-7, the last open-cockpit

At last year's American Waco Club fly-in, John Gerth's 1941 UPF-7 was one of about 40 to return to Creve Coeur Airport (right).

LEFT: DON PARSONS; ABOVE: CAMERON DAVIDSON

biplane the Waco Aircraft Company built (see "Waco World," p. 57, for more on the alphabet soup of Waco designations). "Creve Coeur is a rare airport, one of the best-kept secrets in general aviation," he says. "And it's not just the museum they have. Every hangar has something special in it."

Wacos seem to fit Creve Coeur: They were built in the 1920s and '30s, and they are perfect for joyriding (most can accommodate two passengers and a pilot). Despite their almost endless variations,

DON PARSONS

CAROLINE SHEEN

Clockwise: John Mullen and the Zenith. Al Stix loves Stearmans. John Cournoyer with a 1926 Ryan M-1.

LEFT: CAMERON DAVIDSON

The cavorting Cubs below belong to a fractional ownership franchise based at the airport. One Cub still has shares available.

Wacos are simple, reliable, and "great fliers," according to Stix. The airport's Historic Aircraft Restoration Museum, which comprises three hangars packed with 50 airplanes, features several Wacos. There's also a 1916 Sopwith Pup with the original 80-horsepower Le Rhône rotary engine, a Taylor E-2, father of the Piper Cub, which cruises at 65 mph, and the only flying de Havilland Dragon Rapide in the country (see "Restoration: Delightfully de Havilland," Feb./Mar. 2002). All but a couple of the aircraft are flyable—"the two or three that no one has yet had the nerve to try," says Stix. He has written a clever catalogue (on sale in the admin building) with affectionate descriptions of the aircraft handling characteristics, but the occasional tours he leads through the hangars are gruffly unsentimental. "Of course, if these airplanes were any good, [airplanes would] still look like this," he says.

Cournoyer usually has several aircraft under restoration at once, and his energy as a collector thrills the airplane voyeurs around Creve Coeur. "How many do you own?" I ask him. "I don't even know," he says. (A quick Web search turned up 21 Wacos and a like number of other types that he owns or co-owns.)

Terry Chastain, a retired oil well troubleshooter, has restored many of Cournoyer's aircraft. "We finished five airplanes in three years," he says. "John does a lot of the work." Chastain, who got his pilot's license on his 16th birthday, owns the only 1933 Flagg F-13 ever built. Designed by Claude C. Flagg of the short-lived LaSalle Aircraft Company in nearby Joliet, Illinois, the aerobatic airplane is only 16 feet from spinner to tail and has a 145-hp Warner Super Scarab engine. Chastain spent 11 years

ROBB GESSERT

restoring it from pieces to the jewel-like sportster it is today: "5,263 hours and 15 minutes," he says.

Perhaps his greatest work of art is in the hangar next door: a 1952 Rawdon T-1, which he and his brother Phil, today a corporate pilot, helped their dad, Jack, restore in the late 1970s. The Rawdon has won seven awards, including Reserve Grand Champion in the Classic category at the Oshkosh, Wisconsin fly-in three years running. The late Jack Chastain, who worked for Rawdon Brothers Aircraft Company in Wichita, Kansas, had demonstrated a similar tandem-seat trainer to potential customers, including the governments of Colombia and Ecuador in 1952. On that trip, his wife May Belle occupied the Rawdon's back seat. (Colombia bought three.)

As Chastain tells the story of the Rawdon, I'm watching him work on yet another Waco for Cournoyer, this one, Chastain says, for sale, "though John may have seller's remorse. He usually does. That's why we painted it yellow." Cournoyer isn't fond of yellow airplanes, explains Chastain, so it's easier for him to let them go; Stix loves yellow.

Cournoyer is taciturn, Stix is talkative. Cournoyer loves Wacos, Stix goes for Stearmans. Both are married to women named Connie. Connie Stix managed the airport for years and is there every Sunday. She helped Stix, Cournoyer, and John Mullen transform a 34-acre airport into a 285-acre one with a 4,500-foot concrete runway and a 3,120-foot grass strip, which the owners maintain because the airplanes equipped with tail skids can't operate on pavement and because some pilots think it's fun to land on grass. They've built about 100 hangars.

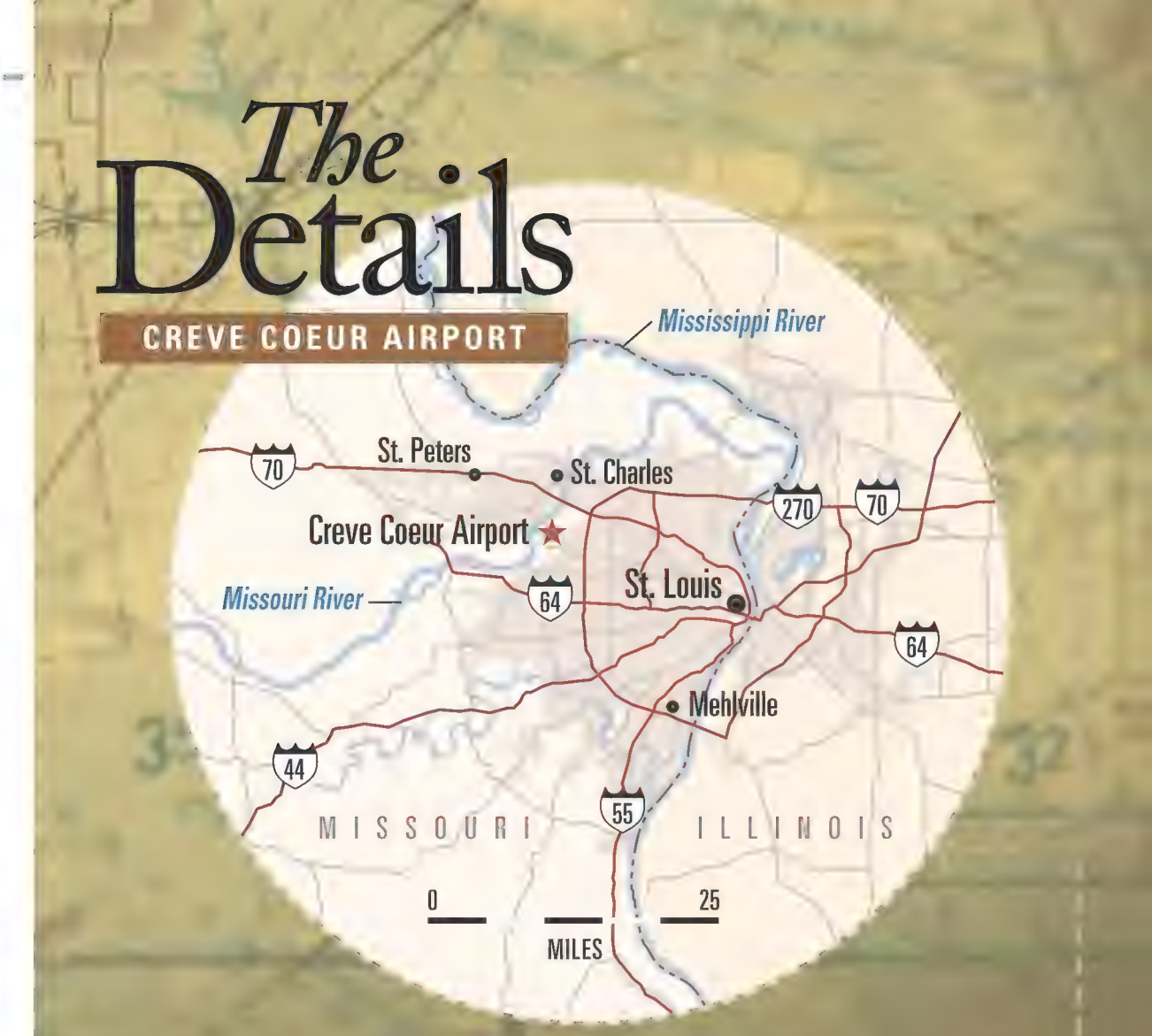
Stix says he and his partners originally decided to sell rather than rent the hangars because they needed the income to make payments on the $540,000 note they took on the airport. It turned out to have been a providential decision.

The 1993 Mississippi River flood, which claimed 50 lives and caused $15 billion in damages nationwide, left the airport under 20 feet of water. "We flew over a few times," says Stix, "and we couldn't see any buildings. We thought they had washed away, but they were just under water."

To the people of Creve Coeur, time is marked "before the flood" and "after the flood." Everybody has photographs. Everybody remembers the call from the airport owners as the river was rising: "Whoever can move an airplane, move an airplane." Out of 200 aircraft, 12 were lost.

Stix's partner, John Mullen, who had worked as a physicist at McDonnell Douglas in St. Louis and was wise in the ways of government contracts, had managed to have the airport designated a reliever for Lambert-St. Louis International. The designation won them federal financial aid for clean-up and repairs.

When the waters receded, eight feet of Missouri river bottom was left behind. "If the hangars had only been rental units," says Stix, "the tenants would have most likely found other places to put their



MAP: JUAN THOMASSIE

CREVE COEUR AIRPORT (1H0) lies four miles northwest of St. Louis, Missouri, about seven miles from Lambert-St. Louis International Airport. Harrah's Casino is three miles away on Maryland Heights Expressway. For a good meal, the locals favor Satchmo's in Chesterfield.

CAROLINE SHEEN

DON PARSONS

The Cessna 120-140 Association flew into Creve Coeur last fall, lining up their fleet of classic taildraggers along the airport's 3,120-foot grass runway. Left: The Question Mark *is a 1932 Waco CTO ("T" for Taperwing). Phil Chastain is about to help Dan Mueller climb aboard.*

ROBB GESSERT

CAROLINE SHEEN

The British had their Tiger Moths, Americans flew Stearmans, and Luftwaffe pilots trained in Bücker Jungmanns. Dan Mueller uses his Bücker to have fun. Above, right: A sure sign that you're at a small airport—bikes. A sure sign that you're at Creve Coeur—people dining in the party hangar.

aircraft." As owners, the pilots stayed, cleaning and salvaging what they could.

The American Waco Club couldn't come in the summer of '94 (still too soggy). Stix moved his cooking operation to an airport in nearby St. Charles. "They came back, though," says Waco club member Ruthie Coulson of the people at Creve Coeur. "They fought hard. Al and Connie and all of them. They're real doers. They pulled together and now look at what they have."

The facilities at Creve Coeur are a reflection of what the owners were seeking when they bought the field: a better place than where they had been. Stix remembers working with his friend John Mullen on the Corsair they owned together at Arrowhead Airport, not 10 miles from Creve Coeur. "We were rebuilding the Corsair, and [when it rained] the hangar kept filling up with water," he says. "It was kind of an unsatisfactory situation to be in with power tools," he adds in characteristic deadpan. "We had this wonderful idea that all we had to do was just buy this airport. The more scotch-and-waters we had, the better it sounded."

The fact that an airport was there to buy is the result of a farmer's ambition for his son, according to retired machinist Jack Oonk (pronounced "unk"), who comes to his hangar at Creve Coeur almost every day to work on his Cessna 195.

Oonk's first airplane was a Luscombe, which he bought in 1953. That summer he hired an instructor for $3 an hour to teach him to fly it. Oonk went flying with two friends, Sid Coates and Aiden Cash. "Sid Coates—he had a Cub—was flying around in the evening west of Lambert," says Oonk, referring to what is now Lambert-St. Louis International Airport, "and the farmer waved him down. The farmer wanted his son to learn to fly, so Sid and the farmer struck a deal." The farmer, Norman "Ducks" Dauster, mowed a grass runway and put up a few shade ports on a 34-acre parcel of land. Coates, who was an engineer, designed a large hangar that today doubles as the party room, and Oonk designed the door for it.

"On a nice summer night, somebody would say 'Come on, let's go flying.' We'd park a car at each end of the grass strip with the lights on." To illuminate the runway's edges, they would fill six Coke bottles wth coal oil, stuff them with wicks, and use them as lanterns.

Eventually a 3,000-foot asphalt runway was laid. And that was pretty much the state of affairs when John Cournoyer, who had several airplanes based at the airport, learned the land was up for sale.

"The guy who owned the driving range across the street offered $1,000 more an acre than we did," says Stix, "but Ducks didn't want it to be a golf course. He wanted it to be an airport."

"This is a neat little airport here," says Bo Mabry, who has flown his Cessna in from South Carolina. "Ya'll are lucky. Ya'll are real lucky," he says to a group of Creve Coeur natives standing nearby. Like the chorus in a Greek drama, five or six Creve Coeur airport bums are usually close at hand to comment on events and accept compliments from visitors. They know they are lucky. They nearly lost the airport, and that brush with disaster undoubtedly brought them closer together. Unfortunately, another pair of tragedies brought them closer still.

Talk to folks at Creve Coeur for a few minutes, and inevitably somebody will mention Bud Dake. For a man who, his friends say, spoke so little, Dake had a tremendous impact. He was one of the first, there in the early days with Jack Oonk, and he was one of the gurus: Everybody at Creve Coeur learned something about airplanes from Bud Dake. Dake flew Monocoupes and said to an *Air & Space/Smithsonian* reporter the year before he died: "It's like Ford or Chevrolet. You decide which one you like and you stick with it."

Dake crashed in a Monocoupe on a fine Saturday afternoon in the summer of 2004; he and his friend Kenny Love were both killed.

Not three weeks after Dake's death, Creve Coeur suffered another shock. John Mullen died. The coroner reported that he had been poisoned with arsenic. The crime remains unsolved.

"We all felt like we'd been hit in the stomach," says Don Parsons, a corporate pilot who spends every weekend ("every chance I get") at the airport. "We just couldn't breathe."

In addition to having secured Creve Coeur its reliever designation, Mullen started a project at the airport that everybody felt a little pride in: Where else but at Creve Coeur would you find a 1929 Zenith Z6a being restored? A six-passenger biplane that Mullen bought at an auction in 1986, the Zenith was built at a time when every town seemed to have an airplane manufacturer; this one was in Midway City, California, and it stayed in business long enough to build seven airplanes.

Glenn Peck, who restored the aircraft for Mullen (he had worked on it for eight years and had finished its taxi tests just before Mullen died), believes the Zenith is airplane no. 3, one of two purchased by Bennett Air Transport of Boise, Idaho, and used to haul freight.

COURTESY CONNIE STIX

CAROLINE SHEEN

Waco World

MADE TO ORDER

By 1927, 40 percent of all small aircraft flying in the United States had been sold by the Advance Aircraft Company. Begun in 1920 as the Weaver Aircraft Company, it returned to its Waco name in 1929 and designated its wide variety of custom-made models by an infamous three-letter code: The first letter represents engine type; the second, the wing and sometimes the fuselage style; and the third, the type in a series. (A good de-coding exists at *aerofiles.com/wacodata.html*.) Waco's UPF-7 was the best-selling model and is the most plentiful today; about 600 were sold between 1937 and 1942. So enduringly popular are Wacos that in 1986 Waco Classic Aircraft of Battle Creek, Michigan, began producing Waco YMF biplanes under the original 1934 FAA type certificate.

CAMERON DAVIDSON

The airport museum is crammed with Wacos, but there are rarer treats. The beak of a 1929 Brunner-Winkle Bird sneaks into this frame. And a Russian amphibian Shavrov Sh-2 survived a 1993 flood but had to be totally rebuilt (left, top).

CAROLINE SHEEN

The Chastain Dynasty (right to left): corporate pilot Phil with wife and student pilot Betty and their Yak 52, pilot and restorer Terry, and May Belle with sidekick Niki. Below: Almost every hangar at Creve Coeur houses a museum-quality airplane, but Dot and Ken Kotik's Piper L-4B liaison aircraft also resides in a museum-quality hangar.

A.A. Bennett's nephew Ed Burnett, now in his 80s, was seven years old when he spent time with his uncle at the company in Idaho. Mullen found him while he was researching the airplane's history, and Burnett came to the airport to see the airplane he used to fly in as a kid. He told Peck that the maroon color was wrong. "He said this was much prettier than the original," Peck says. Burnett told Peck stories about the air transport business, including his memory of helping his uncle load a cow in the airplane's cabin. "He'd carry anything he could get through the door," says Peck, who restored the airplane based on nine black-and-white photos. "Mining equipment, groceries, tourists, supplies to the miners. And of course the cow."

Peck, who restores and maintains the aircraft in the airport's museum, has restored 16 airplanes since 1975. He is at work now on a de Havilland D.H. 4, the workhorse of early airmail service in the United States.

Don Parsons tells me I can't really appreciate Creve Coeur unless I see it from the air, and offers to take me with him to a Sunday pancake breakfast at nearby Shelbyville airport, just across the river in Illinois. Parsons, the very proud owner of a 1946 Fairchild 24R, a high-wing monoplane with a comfortable cabin, has become the unofficial—that is, volunteer—airport photographer. (Some of his photographs accompany this article; others can be found at *www.airspacemag.com*.) "Al helped me buy my airplane," he says. As with several airplanes on the field, Stix is part owner of the Fairchild.

Under the Fairchild's wing, Creve Coeur looks particularly orderly on this beautiful calm morning. The hangars are arranged in eight neat rows along taxiways. Later, the doors will open and people will stroll from one hangar to the next or cruise on one of several bicycles propped at hangar doors to make the circuit among their friends.

Clouds reflect in the lake by the airport and in the ponds of surrounding farms. We fly over a tiny church, its parking lot full. To the south lie a ghost of a runway and abandoned hangars—what remains of Arrowhead airport, a warning that it takes a lot of hard work to keep little airports going.

After the shortest hour I've ever spent, we bounce down on Shelbyville's grass strip. Bob Howie shows us his collection of Wacos. Standing next to one 1927 beauty that has flown some 450 hours in almost 80 years, Parsons says, "Hear that?" I hear nothing but the skreeking of grasshoppers in the adjacent field. "That's all they heard

DON PARSONS (2)

when they were first flying these airplanes," he says. No noise from interstates, no noise from anything.

Back at Creve Coeur, Stix has the industrial-strength barbecue going, and I'm sitting at one of the picnic tables across from the two Connies and next to Greg Kuklinski, a Piper Tri-Pacer man, currently airplane-less. Kuklinski has been telling stories of what he calls "the Chastain dynasty" with occasional mirthful contributions from May Belle Chastain, who's at the next table. Kuklinski says that if you hang out at the airport enough you can get a ride or even borrow an airplane, but it helps if you're good-looking. At that moment Phil Chastain taxis by in a Yak 52 military trainer that he co-owns with Stix. Caroline Sheen, the magazine's picture editor, is waving to us from the back seat.

"See what I mean?" Kuklinski cries out. "I've never gotten a ride in that airplane."

"Me either," says 81-year-old May Belle. "I can't get in. I can't climb that high."

Dan Mueller, having survived *The Question Mark*, has joined the group around the picnic tables, and people are talking about Les Heikkela, who has recently bought a P-51 Mustang. "He's flying the hell out of it too," says Kathie Ernst, a corporate pilot and engineer who's swinging on the porch swing. The chorus nods its approval. This is life as it should be, think the people of Creve Coeur. Work hard to buy the airplane of your dreams, then make the time to fly it as often as you can.

Haus, the airport dog, is lying motionless on the porch. He belonged to a family who lived next door. After they moved and took the big black Labrador with them, he ran away and made his way back to the airport. The family fetched him, but Haus came back again. Finally, the family gave up and left him to the care of airport manager Bob Cameron.

Everybody at Creve Coeur understands why Haus kept coming back, and any one of them could give you a dozen reasons. But I think they'd be happy to let Bud Dake have the last word. When a reporter for *Air & Space* asked him a few years ago why he owned a hangar at the airport, he said, "It's so quiet down by the river bottom."

If an F-14 is, as the bumper stickers say, the sound of freedom, then Don Parsons' Fairchild 24R (above) is the sound of contentment. Left: A little bit louder now—Les Heikkela's P-51D is one of the few fighters at the airport, where...

CAROLINE SHEEN

... many biplanes fly.

GEORGE KOUNIS

ROBO REPAIRMEN

THEY'RE SMART, THEY'RE DEXTEROUS, AND THEY DON'T NEED SPACESUITS.

BY MICHAEL BEHAR

UMD SPACE SYSTEMS LABORATORY

The Ranger robot in one of its early incarnations, practicing a task underwater.

On a sweltering summer afternoon, Dave Akin, an associate professor of aerospace engineering at the University of Maryland, heaves open a thick steel door and directs me to a stairwell inside a red brick monolith called the Neutral Buoyancy Research Facility, part of the school's Space Systems Laboratory in College Park. The building houses a 367,000-gallon cylindrical fiberglass tank of sparkling blue water used to conduct experiments under weightless conditions, or as close as we can get to weightlessness here on terra firma.

Akin is clad in sandals, cargo shorts, and a souvenir T-shirt from NASA's nearby Goddard Space Flight Center that's stained with barbecue sauce from a school picnic he attended at lunch.

NASA

Robonaut was designed to work outside the space station so that astronauts wouldn't have to. Despite its sophistication, its only work to date has been in the lab.

Plump, bald, and bespectacled, he greets me with a husky handshake and a warm smile, then bounces up five flights of stairs to the top-floor control room, where a team of grad students is about to lower the Ranger space robot into the water.

Autographed astronaut posters adorn the walls of the room; junk food is strewn across a long conference table. Near the door is a dinged-up computer that's missing its front panel. This is Ranger's main processor. A thick gray cable snakes from the box through a hole in the wall and into the water tank, where it's plugged into a data port on Ranger. "That's his brains," says research engineer Stephen Roderick when he catches me tapping on the box with my pen.

Minutes later Akin is outfitted in scuba gear and hovering 25 feet down near the bottom of the tank as Ranger slowly swings its arms to and fro, pivots at the waist, rotates its wrists, and, like an irate lobster, clenches and opens its steel pincers.

Akin began building underwater robots like Ranger in the 1980s as part of a NASA-funded effort to learn how robots could help astronauts do their work in orbit, including servicing the Hubble Space Telescope.

So far, Ranger has struggled with its mission *du jour*: inserting a model of the Hubble's Wide Field Camera into a drawer-like slot that matches the one on the actual telescope. Akin is busy snapping pictures with a digital camera and hardly notices when his 2,000-pound robot suddenly jerks backward after one of its joints gets jammed.

Roderick, who everyone calls "Kiwi" because he's from New Zealand, operates Ranger via joystick and keyboard commands while watching its movements over TV monitors linked to five underwater video cameras. At least twice during the three-hour experiment, Ranger contorts itself into yoga-like positions that confound Roderick. Bubbles trickle from its housing, indicating leaks. And during the transition between certain movements, Ranger twitches unpredictably. But when Akin surfaces, he's beaming. "That went really well," he says, "considering that was the first time Ranger tried those moves."

This all happened last summer, at a time when official government interest in space robotics had reached a historic high. Six months earlier, NASA Administrator Sean O'Keefe announced he was canceling a long-planned shuttle mission to replace Hubble's aging batteries and gyroscopes and install an advanced camera and spectrograph. Worried about astronaut safety following the *Columbia* tragedy, O'Keefe wasn't willing to risk lives to upgrade the telescope for the fifth time, no matter how much astronomers or the general public wanted it.

So the call went out to industry: NASA wanted to know if a robotic spacecraft could be built to carry out the servicing mission *sans* humans before 2008, the year in which the telescope's batteries and gyroscopes are expected to fail. Akin, whose Ranger had been practicing some of those very tasks for years, answered NASA's call. So did robotics experts from labs elsewhere in the United States, in Canada, and around the world.

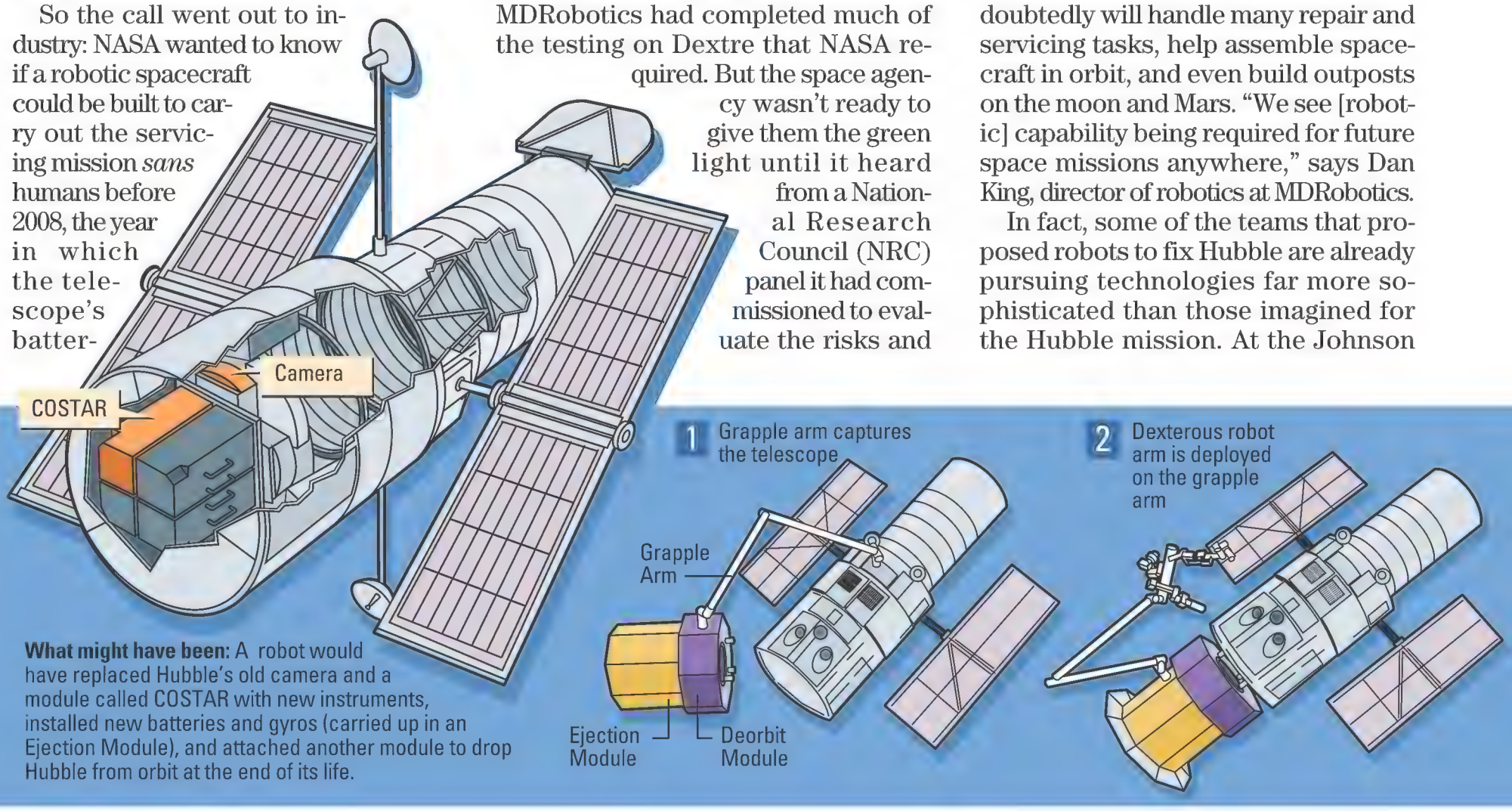
MDRobotics in Brampton, Ontario, submitted one of the most promising proposals. The company had finished construction of Dextre (the nickname for "special-purpose dexterous manipulator"), a remotely operated two-armed robot already ordered to help astronauts service and maintain the International Space Station (ISS). NASA project managers knew that to launch a repair robot by the 2008 deadline, there was no time for research and development. So the agency asked MDRobotics to begin production of a second Dextre that could be launched on an unmanned rocket, then deployed in orbit to complete the tasks originally intended for the shuttle astronauts. Dextre would replace the Hubble's batteries and gyroscopes, install the spectrograph and camera, and attach a rocket-equipped module that could deorbit Hubble and safely steer it into the ocean at the end of its life.

By last August, engineers at MDRobotics had completed much of the testing on Dextre that NASA required. But the space agency wasn't ready to give them the green light until it heard from a National Research Council (NRC) panel it had commissioned to evaluate the risks and costs of a servicing mission to Hubble.

The panel's final report, released last December, more or less concluded that it was impossible for robotic technology to be developed in time to save the Hubble. The committee, which included robotics experts, Nobel-Prize-winning astronomers, and veteran astronauts, relied in part on an exhaustive evaluation done by the Aerospace Corporation, a federally funded R&D think tank based in El Segundo, California. That study concluded it would take five and a half years to ready a robotic mission—nearly double what it would take to prepare a shuttle mission, and longer than the telescope's predicted remaining lifetime.

As a result, NASA killed the Hubble robotic servicing option outright—and, for that matter, a shuttle servicing mission as well. The decision to scrap the telescope angered astronomers, and was a blow to ambitious roboticists like Akin, who'd hoped to prove their stuff by rescuing one of NASA's most prized possessions. But Akin and others are philosophical, and say that not getting a crack at servicing Hubble is only a short-term setback. They believe that as we extend our reach farther into the Solar System, robots undoubtedly will handle many repair and servicing tasks, help assemble spacecraft in orbit, and even build outposts on the moon and Mars. "We see [robotic] capability being required for future space missions anywhere," says Dan King, director of robotics at MDRobotics.

In fact, some of the teams that proposed robots to fix Hubble are already pursuing technologies far more sophisticated than those imagined for the Hubble mission. At the Johnson



What might have been: A robot would have replaced Hubble's old camera and a module called COSTAR with new instruments, installed new batteries and gyros (carried up in an Ejection Module), and attached another module to drop Hubble from orbit at the end of its life.

Space Center in Houston, for example, engineers recently added a seven-jointed leg to their humanoid space robot Robonaut. With its new appendage, Robonaut can simulate climbing in zero G. It features a built-in CPU, five-fingered hands, and more than 150 sensors. Project engineers claim that it has dexterity comparable to that of a gloved astronaut and better range of motion. "Robonaut could light birthday candles on my kid's cake," quips former project manager Rob Ambrose.

"Humans in space will want to have excellent tools, and some of these will surely be robotic," says Rud Moe, who manages the Hubble servicing missions at Goddard. "In other cases, the robots will serve very well where humans don't dare to go—or can't go."

After outfitting ourselves in lab smocks, donning white shower caps, and inexplicably jumping up and down on a blue floor mat (I later learn it's to discharge static), Paul Cooper, vice president of business development and R&D for MDRobotics, takes me inside the company's 18,000-square-foot clean room. Three enormous Canadian flags hang from the rafters. "Don't touch anything," says Cooper, reminding me that even the slightest bit of static could short out one of the many electronic components carefully positioned on lab benches around the room.

The 3,600-pound Dextre robot is toward the back, where it's suspended from a block-and-tackle rig that allows engineers to evaluate its performance in simulated zero gravity. "Repairing Hubble is such a noble mission, crossing the boundary of science and reaching into the public interest," gushes Cooper, who stubbornly maintains that a robotic servicing mission would have been a viable option. "It's not just some pie-in-the-sky design idea. Dextre really exists. And it has already been built and tested for the ISS."

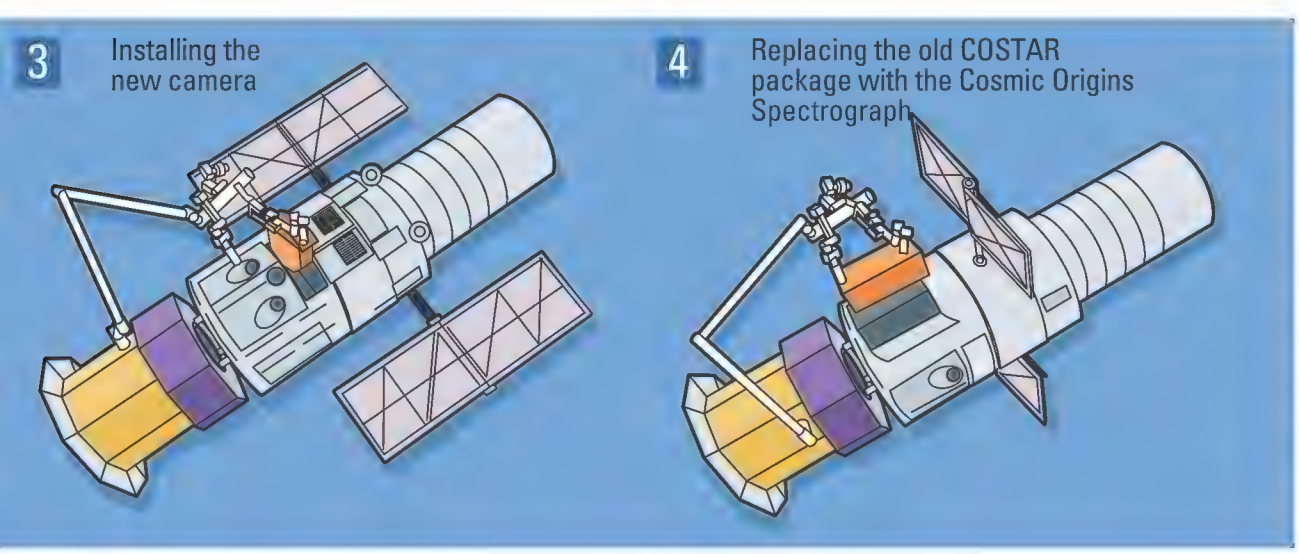
In Congressional hearings last February, members of the House Committee on Science questioned Cooper about the risks outlined in the NRC report—things like the time lag in robotically executing commands from Earth, and the feasibility of latching onto Hubble, which lacks a docking interface. Cooper pointed out that before a Hubble servicing flight would take place, other space missions would solve these technical challenges. Two such missions were launched this spring—NASA's Demonstration of Autonomous Rendezvous Technology (DART) and the Air Force-sponsored XSS-11. Both were designed to prove that one spacecraft could meet up with another in orbit and work in close proximity, safely, with no human supervision.

"By the time we launch [Dextre]," Cooper argued in his testimony, "there's going to be nothing left for us to do but actually go up there and do the mission, because everything we could possibly think of will have been covered by that point." But DART had only mixed success, getting close to its target but then actually bumping into it.

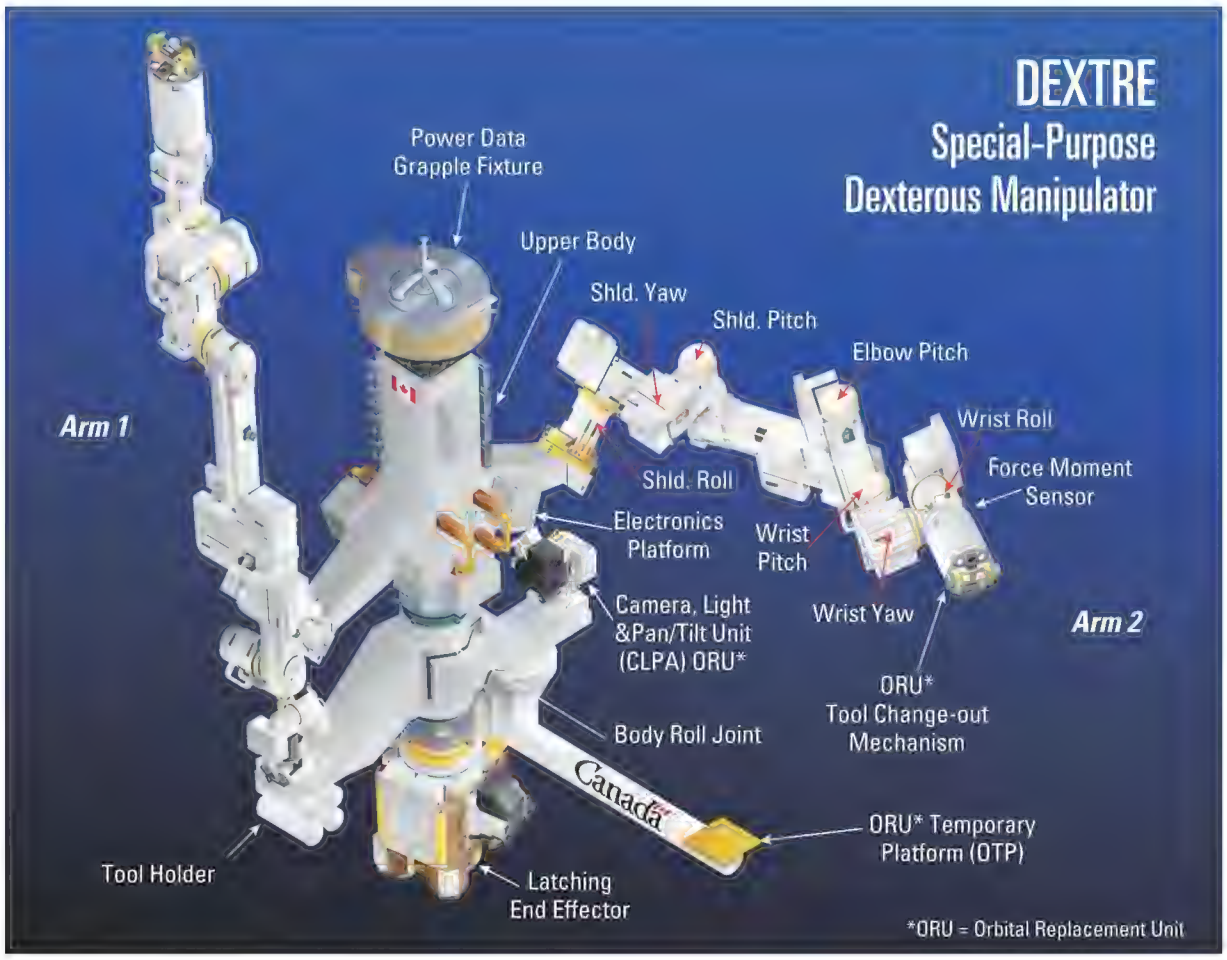
Last summer, when robot rescue was still a possibility, astronauts and technicians at Goddard practiced maneuvers with Dextre on a life-size repli-

NASA

Swapping out a Hubble instrument in 1997. Could a robot do this?



ILLUSTRATIONS BY JUAN THOMASSIE



COURTESY CANADIAN SPACE AGENCY

NASA

When NASA was considering a robot to rescue Hubble, it turned to the Canadian-built Dextre out of familiarity—it had already been built for the space station. Robonaut (left, with astronaut Nancy Currie) has nimbler hands but is more experimental.

ca of the Hubble. The tests even simulated a two-second delay in Dextre's response to human commands radioed from Earth. Cooper plays me a video from the Goddard shakedown that shows Dextre opening and closing panel doors on the Hubble mockup, twisting bolts, and yanking out power cords. Before Dextre can begin each task, it must switch the tool affixed to its "end-effector." The device is similar to a dentist's multi-tool driver: Dextre can swap out the heads—one for turning a screw, another for clamping onto a cable, a third for rotating a knob or opening a latch.

On the video, the tasks seem simple enough. And Cooper reminds me that once Dextre is joined with Hubble in orbit, there will be no rush to finish the job: "One of the nice things about a robotic servicing mission is it doesn't matter how long it takes. There are no astronauts to be fed, no shuttle landing schedule. Dextre could take days and weeks if it wants, trying different things over and over again—all of which enhances its probability of success."

Of course, here inside NASA's lab, Dextre and the Hubble replica are in a controlled setting. Nobody knows exactly what would happen if they'd been drifting side by side at 17,500 mph, hundreds of miles from Earth. The NRC panel worried that the robot could easily be thrown by unexpected glitches, like connecting pins that turned out to be bent instead of straight.

Kathy Thornton, a former shuttle astronaut, performed the first repairs on Hubble during a 1993 mission. She points out that most of the panels, latches, doors, and connectors on the telescope were designed for humans. "All those interfaces that were made for people to use would be more difficult for robots," says Thornton, who left NASA in 1996 to teach engineering at the University of Virginia in Charlottesville. "Some of the connectors would be very hard to change, and not many of the end effectors [on the robots] are made to capture things when they start floating around." Thornton says that a robotic servicing mission would have been "a great engineering exercise" but that it could have been more likely to damage Hubble than an astronaut repair mission.

Even a relatively simple teleoperated docking can end in disaster, something I witness firsthand inside a rectangular lab at MDRobotics known as the Bowling Alley. Engineers George Bailak and Andrew Allen are trying to develop a remotely operated spacecraft that can dock with a variety of satellites. In the center of the lab are two granite platforms positioned side by side. The engineers have placed a 1,500-pound satellite replica on one and their 260-pound robotic coupler on the other. They both rest on circular pads called precision air bearings. When high-pressure nitrogen is pumped through the bearings, the spacecraft begin to float like pucks on an air hockey table (this is Canada, remember), gliding a few millimeters above the pads.

After a pre-programmed computer sequence initiates the docking procedure, short bursts of pressurized air begin to slowly propel the coupler toward the satellite. A barbed hook on the end of the coupler is supposed to snag the inner lip of the satellite's thruster cone. The two craft barely touch when the satellite suddenly swings sideways. A second try produces a similar result. Only on the third attempt—with Bailak and Allen physically nudging each craft to maintain the proper alignment—does the docking succeed. Later, I try the same procedure on a simulator. After a promising start, I crash the docking craft into the virtual satellite, tearing off half its solar panels and sending it into a death spiral.

Bailak and Allen brush off my cosmic train wreck as a minor hiccup along the robotic servicing learning curve. Besides, they say, autonomous ren-

dezvous and docking are precisely the problems that projects like DART and XSS-11 are meant to address. DART's program manager, Jim Snoddy, calls his mission "a prototype of many things to come," including the orbital assembly of spacecraft bound for the moon and Mars. "When we start putting more pieces in space, we're going to have to start putting them together," he says.

A major hurdle will be developing a robotic arm that can adjust its sensitivity as it pushes and pulls on connectors and cables. Ideally, a robot would react to physical resistance much as a person does—by turning a screw more slowly and carefully, for instance, if it felt the threads beginning to strip.

Gerd Hirzinger, director of the Institute of Robotics and Mechatronics, part of the German space agency, DLR, hopes to overcome this problem with a remotely operated mechanical arm called ROKVISS (Robotic Component Verification on ISS). ROKVISS is a double-jointed arm about two feet long, with a self-contained power supply and a finger-length stylus tool. A Russian resupply craft delivered ROKVISS to the space station in December. It was mounted to the outer wall of the Russian Zvezda module, where it could be operated from a ground station located about 15 miles from Hirzinger's lab outside Munich.

In March, ROKVISS completed its first set of maneuvers, "proving that the concept of torque-controlled joints" is mature enough to work in space, says Hirzinger. The joints, he adds, are "similar to human muscles—you can them make stiff or soft." The ROKVISS arm also incorporates a stereo camera. According to Hirzinger, once the robot makes contact with a contoured shape, the arm can either maintain an even pressure anywhere along the object, or apply "high-fidelity force feedback" to vary the pressure. Imagine hand-sanding an intricately carved wooden table leg: If you don't adjust your pressure to accommodate the leg's curves, the finish will become uneven, smoother where it's convex but still rough along the concave surfaces. Hirzinger plans to continue testing ROKVISS aboard the station for a year. "If the joints turn out to work perfectly in space," he says, "then we'll immediately start building a seven-degrees-of-freedom free-flying robot." Eventually, the follow-on system would be used to demonstrate in-orbit satellite servicing.

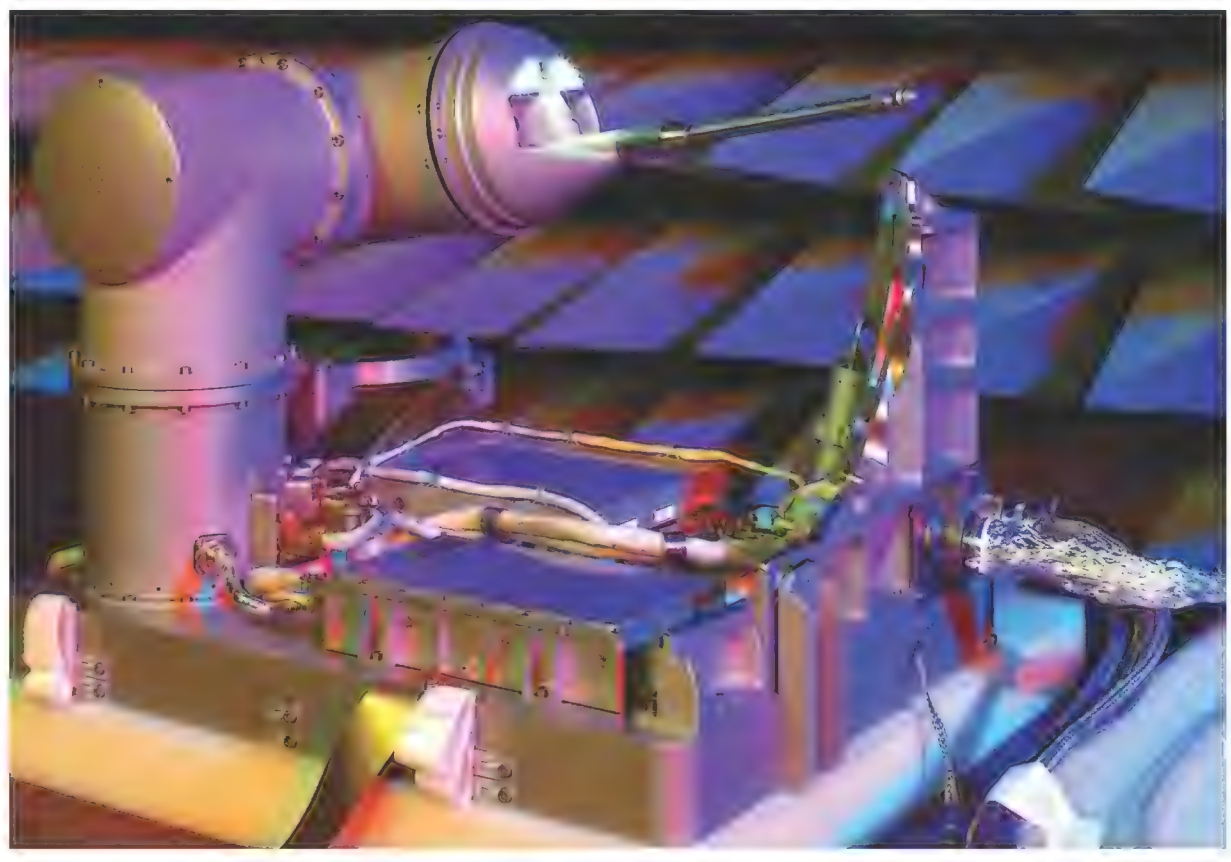
Meanwhile, in Houston, Rob Ambrose's group has built a mobile platform for Robonaut. Funded by NASA and the Pentagon's Defense Advanced Research Projects Agency, Robonaut has simmered along since 1996 as a low-priority technology development effort. Despite its popularity with the press and its Hollywood good looks, the humanoid robot has never been called for an assignment in space.

Ambrose hopes NASA's recent focus on building a lunar base could change things. Recently his team removed the robot's single zero-G leg and mounted its torso to a mobile platform based on the Segway scooter. They wired Robonaut's computer interface directly into the Segway's control system, giving the robot control over its balance and motion. "We would like to put our robots in a precursor role: setting up a work site or habitat on the moon," says Ambrose, who is now looking for a four- or six-wheel platform suitable for rough lunar terrain. "If I were going to be sent to the moon, I would want my habitat already making oxygen, already 72 degrees, holding air, and not leaking."

Back at the University of Maryland, Ranger's successors continue making dives in the neutral buoyancy tank, but now Akin is adapting them for more generic work. His team is also working with NASA's Astrobiology Science and Technology Experiment Program to develop a Ranger-type robot that could collect planetary samples—perhaps on Jupitor's moon Europa.

As for Hubble, the new NASA administrator, Michael Griffin, may reverse his predecessor's decision on a shuttle rescue, but has come out against letting robots save the 15-year-old telescope. No matter—the machines' day will almost certainly come. That's another advantage robots have over humans: They're endlessly patient.

Germany's ROKVISS robot (below) got a workout this year on the space station. A follow-on version (right) might someday service satellites.



(2) DLR/INSTITUTE OF ROBOTICS & MECHATRONICS

COLD FRONT

THE CREWS WHO KEPT P-47 THUNDERBOLTS FLYING IN WORLD WAR II WERE AS TOUGH AS THEIR AIRPLANES.

NEW YEAR'S DAY, 1945, dawned clear and cold for the tired men of the 365th Fighter Group, stationed in Metz, France. Hangars that once sheltered the group's three Republic P-47D Thunderbolt squadrons had been bombed, and the crews were working in maintenance and operations tents they had set up on the flightline. By 9 a.m., the 387th and 388th Fighter Squadrons had already launched their bomb-laden Thunderbolts northeast to search out supply lines and Nazi forces trying to escape eastward. The ground crews waited as the pilots of the remaining squadron, the 386th, donned parachutes and headed out to their airplanes. It was the first day of the seventh year of the Second World War.

That day in the life of the 365th was chronicled in detail by then-Staff Sergeant Charles Johnson, the group's official historian. In his 1975 book *The History of the Hell Hawks*, Johnson reported an exchange between Staff Sergeant George "Moocher" Wasson, a 365th crew chief, and a friend, Staff Sergeant John Lehnert. Wasson was trying to dry a cigarette butt he had just retrieved from the frozen ground, when Lehnert noticed him fumbling with it. "Hell, George, have a Camel!" Lehnert called, beckoning him over with a fresh cigarette. The two stood smoking and talking for a couple of minutes. Just as Wasson resumed his walk to the hangar to fetch a part for his P-47, he heard someone yell, "Look at those P-51s buzzing the field!" Lehnert and Wasson turned together and spotted the oncoming fighters—and muzzle flashes. "P-51s, my ass!" someone shouted. "Those are Germans!"

Sixteen Messerschmitt Bf 109s swept in from the hills north of the field, heading directly for the fully loaded Thunderbolts clustered on steel-mat hardstands. The 109s were part of a last-ditch Luftwaffe strike, a mission code-named Bodenplatte (Paving Tiles). Since the Allies' breakout from Normandy in August 1944, General Dwight Eisenhower's armies had pressed up to Germany's fortified frontier, where supply problems, winter weather, and heavy German resistance had brought the advance to a crawl.

In support of Hitler's Ardennes offensive, Hermann Goering's Luftwaffe mustered its remaining fighter strength for a coordinated surprise attack on the Allies' forward tactical airfields in Holland, Belgium, and France. The pilots, ground crews, and P-47s in Metz were all caught in the open.

As dozens of startled men dashed for cover in nearby gun pits, the German fighters hammered the field with long bursts of machine gun and cannon fire. Bullets and shells from the 109s' propeller-hub-mounted cannon blew holes in the parked fighters. Explosions cracked across the open field as gas tanks caught fire, detonating bombs and ammunition.

BY THOMAS D. JONES AND ROBERT F. DORR

Tech Sergeant Marion Hill, then-chief noncommissioned officer of the 365th's intelligence section (now a retired chemist living in Oregon), remembers diving for the foundation wall of a burned-out barracks. "That first pass was right overhead," Hill recalls. "They just missed us." His luck didn't hold out long. "I heard a whoosh." A shell fragment ricocheted off the foundation and hit him in the face. "I saw my gloves and lower left arm covered in blood." He was hastily bandaged under fire and evacuated on a stretcher.

Meanwhile, on a 388th Squadron hardstand, Corporal Emanuel Catanuto spotted his friend Corporal Lee Weldon trapped in a Thunderbolt cockpit, a German bullet in his thigh. As repeated strafing passes set the airplane afire, Catanuto vaulted to Weldon's rescue. He reached through the smoke and searing heat, opened the cockpit's door, jerked Weldon free, and tumbled backward off the wing. Grabbing Weldon by his good leg, he dragged the blood-soaked mechanic 30 yards to safety. Suddenly, the P-47's fuel tanks and bombs exploded, engulfing the two men in a hail of shrapnel. Both miraculously escaped unharmed.

With crew chiefs on the wings to guide them, P-47 pilots taxi out to join the battle in Belgium in 1944 (opposite). Staff Sergeant Carrol Joy, with armorer Richard Howard and an unkown pilot, training in Myrtle Beach, South Carolina, in March 1944 (below).

CARROL JOY

OPPOSITE: PHOTO BY TOM GLENN/ROBERT F. DORR COLLECTION

RIGHT: GLENN SMITH; TOP: GEORGE R. BROOKING

A P-47 burns after the Germans attacked the Hell Hawks' field in Metz, France, on New Year's Day, 1945 (above). The Luftwaffe didn't escape unscathed. Staff Sergeant Glenn Smith of the 386th Fighter Squadron gloats from the cockpit of a downed Bf 109 (left).

The Army's anti-aircraft gunners had been firing away at the Germans, and that began to take a toll on the attackers: One Bf 109 crashed in flames on the flightline, hurling its pilot from the cockpit. The body tumbled to a stop a few feet from where half a dozen Hell Hawks, members of the 365th Fighter Group, were huddled in a shallow pit. Flight chief Alvin Brady felt little sympathy for the dead German: "They got us into it, after all." Another crew member said: "I saw a ring on his finger. If I'd had something to cut that finger off, I would have probably got that ring off him." Someone else beat him to it.

The surviving Messerschmitts withdrew over the hills, leaving "Y-34 Metz" in shambles. Wounded pilot Carl Riggs, then a second lieutenant, recalls, "There was devastation everywhere. Burning planes were all over the place." Greasy clouds of black smoke spiraled skyward, and the thud of bombs exploding in the fires punctuated the sudden silence. Twenty-two P-47s lay burning on the field, and another 11 were badly damaged. The 386th Fighter Squadron was effectively out of action, and at least 11 men had been wounded. For the Hell Hawks, the raid was a sobering taste of the war they had brought to the enemy. "It was terrifying to be on the receiving end of the tactics we'd been using all along," says Riggs.

Despite the havoc the Luftwaffe had wreaked on Y-34, Operation Bodenplatte was a failure: 40 percent of the 850 attacking German fighters were destroyed or damaged, and 234 attacking pilots were killed, captured, or wounded.

The 365th ground crews, like those in other units hit by the Luftwaffe that day, turned quickly to the business of salvaging and repairing their damaged aircraft. The "ground pounders," as the pilots sometimes called the maintenance crews, dug new foxholes, dragged wrecked airplanes off the field, and patched the ones with reparable damage. Cannibalizing the wrecked P-47s, the ground crews scrambled to turn around the survivors. By sharing aircraft from the two squadrons that had been airborne at the time of the attack, pilots from all three squadrons got back in the air that afternoon.

In the Republic P-47 Thunderbolt, ground crews had a rugged, reliable fighter, perfect for the mud and spartan repair facilities of their forward airfields. It was called "the Jug" because of its milk bottle shape—its beefy construction and the efficient Republic design made it relatively simple to maintain under combat conditions.

Originally designed as a high-altitude interceptor, the P-47 first flew in May 1941. The brutish fuselage was married to a pair of graceful, semi-elliptical wings mounted with eight heavy .50-caliber machine guns. It derived its power from a 2,000-horsepower, 18-cylinder, Pratt & Whitney R-2800 Double Wasp radial engine with a turbo-supercharger. With full tanks, ammunition, and two 1,000-pound bombs, later models weighed in at a hefty 19,400 pounds, more than any other single-engine fighter of World War II.

The P-47D entered combat in March 1943. With Lockheed's P-38 Lightning needed in the Pacific and the superb North American P-51 Mustang still in development, the Thunderbolt filled the need for a long-range escort for the bomber offensive from England. Its massive engine propelled the P-47 to a speed of 433 mph at 30,000 feet.

As the 1944 cross-Channel invasion approached, the Mustang arrived in the European theater and proved both more agile and longer-legged than the fuel-thirsty Thunderbolt. The Ninth Air Force Fighter Command, led by Major General Elwood "Pete" Quesada, needed a sturdy attack fighter to insulate the Allies in Normandy from German reinforcements and support the ground forces after D-Day. The P-47's rugged design and powerful armament were perfect for those jobs.

Unlike the inline powerplants of the Mustang and Lightning, the P-47's radial engine was air-cooled: It dispensed with a radiator and liquid coolant sys-

tem, which were so vulnerable to a lucky enemy shot. More than one Thunderbolt returned to base with a cylinder blown away, its connecting rod dangling. The big engine up front, coupled with armor plate fore and aft of the cockpit, gave the pilot extensive protection from enemy fighters and ground fire. The turbocharger's ducts, running the length of the lower fuselage, protected a pilot's legs from the jarring crunch of an emergency belly landing. Flight chief Alvin Bradley of the 386th Fighter Squadron is adamant about the aircraft he once maintained: "It was the safest, toughest plane to bring somebody back after it was damaged."

In late June 1944, crew chiefs, sheet metal workers, armorers, radio techs, propeller specialists, and engine mechanics of the Ninth Air Force, the U.S. tactical air arm in northwest Europe, crossed the Invasion beaches to meet their airplanes and pilots in Normandy. Just a few weeks after D-Day, nearly a dozen Thunderbolt groups were active on new airstrips, some carved out under enemy fire.

The 365th Fighter Group was typical of the 18 fighter-bomber units serving in the Ninth. After Pearl Harbor, volunteers and inductees had streamed through the Army's basic training and technical schools to fill the ranks of the air forces. Those with the right aptitude, perhaps aided by pre-war experience as gas station attendants or factory workers, were trained as aircraft mechanics.

Twenty-two-year-old Staff Sergeant Guy Bauman, for example, was a truck driver in Illinois when he was drafted in 1942. When the Army sent him to engine school at the Republic factory in Farmingdale on Long Island, New York, he had never even seen an airplane before. He eventually joined the 365th as a P-47 crew chief. With his colleagues, he would linger near the runway for the hour or two their airplanes were on missions. The returning pilots usually notified the crew by radio if someone was missing. "It was nerve-wracking," Bauman remembers. "You worried about that pilot all the time. They were just like a brother to you."

A fighter group like the 365th had three squadrons, each with approxi-

NASM (SI NEG. #90-6982)

Ground pounders in France (right) refueled and rearmed the P-47s as fast as humanly possible. Below: Jugs in fearsome formation.

NASM (SI NEG. #00083262)

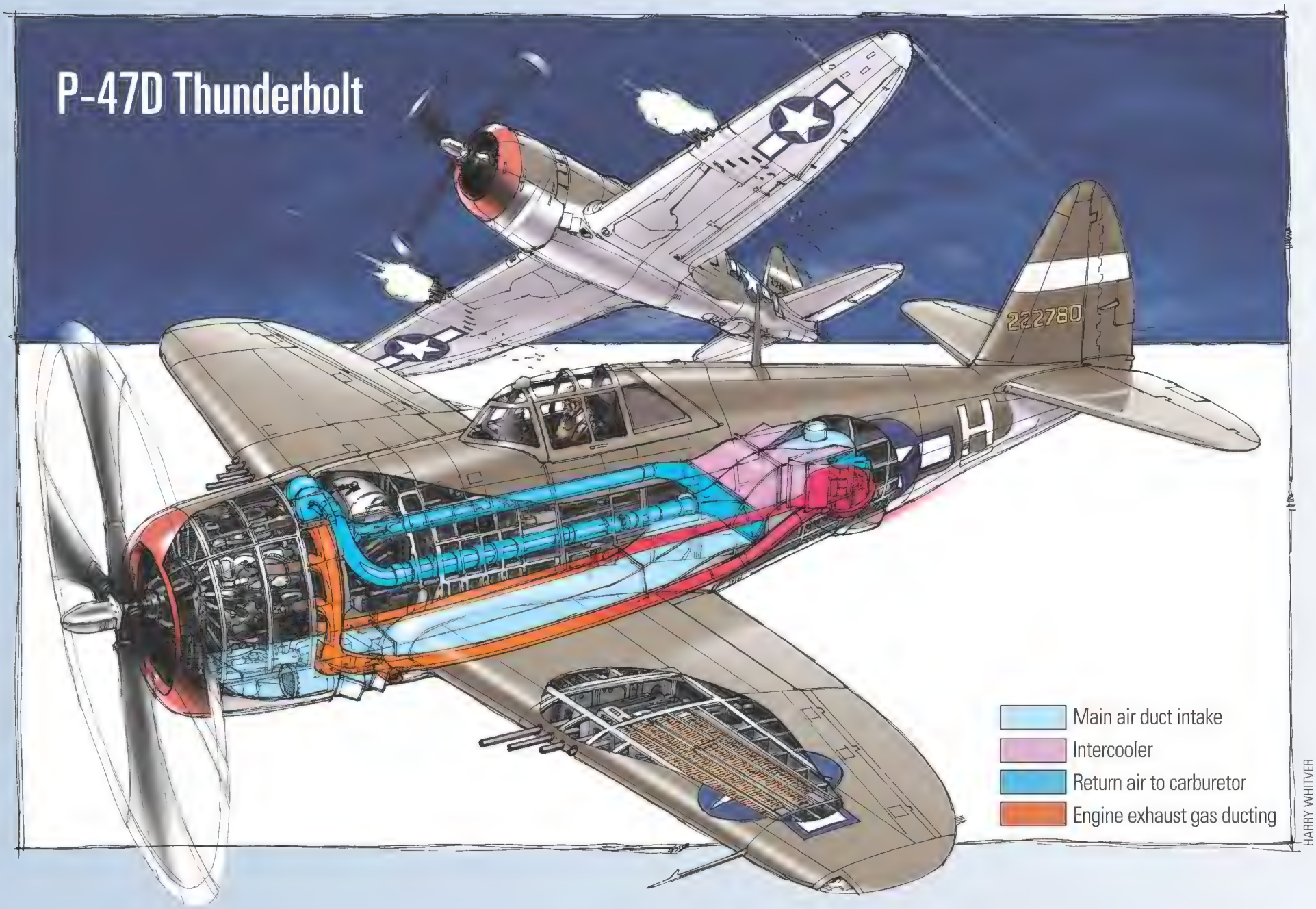
U.S.A.F. COURTESY NASM (SI NEG. #93-11514)

An Eighth Air Force Thunderbolt makes a strafing run on a German flak tower in occupied France (left). The virtually indestructible P-47 was ideal for dive-bombing and low-level strafing missions. Its air-cooled engine made it less vulnerable to gunfire (below).

mately 25 P-47s. Each airplane was maintained by a crew chief and his assistant, along with an armorer to load the .50-caliber machine gun ammunition, bombs, and rockets. A flight chief supervised the teams and looked after eight or nine aircraft. A squadron line chief—a senior non-commissioned officer—assigned cadres of propeller and radio personnel, sheet metal experts, and instrument techs to repair battle damage or broken systems, making sure each fighter was ready before dawn for that day's sorties.

The 365th ground crews trained in Virginia, Delaware, and New Jersey, and arrived in England in 1943 with 15,000 other GIs crammed onto the oceanliner *Queen Elizabeth*. The unit initially flew from England and got its first taste of combat in bomber escort missions across the Channel. After D-Day, with the Allies and the German forces deadlocked in Normandy's hedgerows, the 365th shifted to a forward airfield near Utah Beach, and its work began in earnest.

Charles Johnson wrote that before shipping out to England, the 365th's commander, Colonel Lance Call, issued an edict that "no matter what the extent of damage to the aircraft, it must



HARRY WHITVER

be flying again within twenty-four hours."

The daily routine was simple in concept but relentless in practice. "During combat operations, we woke up the plane with a preflight check," Johnson wrote. "First, we started the engine to check its operation and the performance of the magnetos. We also checked the instruments and the propeller's pitch control. Then came a complete check of the exterior of the plane including the sheet metal, control surfaces, and windshield. Often, bombs were loaded under the wing or on the belly. The fuze on the nose of each bomb was checked to be sure the detonator safety wire was in place.

"When a 110-gallon tank of gas was attached to the belly, glass tubing was used to connect the two pieces of rubber fuel line," one from the tank, one from the airplane. The connection was a constant source of worry for crew chiefs, Johnson recalled. If a rough runway or turbulence broke the glass, would the pilot be forced to abort, or run short of fuel in the heat of a dogfight?

Preflight complete, the ground crew waited for the pilots to arrive in a jeep or truck called the "fish wagon." One man would lug the parachute up to the cockpit while the crew chief helped the pilot climb onto the wing, then lent him a hand with the parachute straps. Finally, the crew chief lay prone on one wing, and hung onto one of the protruding .50-caliber gun barrels to perform one of the most unusual duties of a Thunderbolt ground crewman: guiding the pilot down the taxiway.

From the cockpit, the view forward while taxiing was blocked by the huge cowl of the Pratt & Whitney radial. Pilots were taught to make continuous S-turns to clear the route ahead, but so many Thunderbolt tails were clipped by the following airplane's prop that the crew chiefs had to take on a new job as "copilots." Using hand signals, the enlisted man directed his pilot to the end of the runway, then hopped down just before takeoff.

Flight chief Don Shilling, a tech sergeant from the 406th, liked to accompany his airplanes out to the runway in a jeep. "You could always tell if your airplane was running good when it was under full blast—you know—if she was hitting on all 18 [cylinders]," he says.

The P-47's mission—dive-bombing and low-level strafing—brought other headaches to the ground crews. All too often they saw their airplanes return with bent propellers, holes in wings and fuselage, and traces of the battlefield—dirt, stones, shrapnel, branches, leaves—embedded in the wings and cowling. But it was precisely the P-47's ability to limp back with seemingly fatal damage that made it the ideal aircraft for ground attack.

Pilots returned with airplanes flayed by flak from German gunners, whose 88-mm and quad-mounted 20-mm guns were deadly at medium and low altitudes. Carrol Joy, a staff sergeant from the 406th, reports that his airplane once returned with 105 holes in it, and Shilling saw a P-47 return so badly shot up that "you could crawl through those holes in the wing."

Warren Dronen, who flew 80 combat missions with the 362nd Fighter Group, once had his Thunderbolt perforated by flak, holes stitching his wing with "a sound like a sewing machine." He managed to get back safely. With the prop windmilling to a stop, his crew chief jumped up on the wing, took one look at the battered airplane, and said, "Jeez, Lieutenant! Why the hell did you bring that thing back here?"

Ground crews saw the evidence of close combat on their airplanes, and in the faces of their pilots, every day. Yet they seldom got a direct taste of war. "You didn't actually kill somebody face to face," wrote Frank Mangan in his 2003 book *Mangan's War*. "You merely helped from a distance." But as the tempo of fighting increased near the German frontier, the sustained air-to-ground onslaught inevitably touched everyone.

In Metz, a 365th gas truck driver was fatally wounded by the propeller hub from a crashing Thunderbolt. In Florennes, Belgium, a crew chief was struck by a stray shell from the guns

COURTESY OF FAIRCHILD VIA NASM (SI NEG. #A-1195)

Of the 15,683 P-47s built, 12,608 were D models. The "razorback" configuration was modified on later P-47Ds to a bubble canopy, which provided pilots a clearer view once they were in the air, but the imposing engine cowling made it impossible to see down the runway on takeoff. In 1.35 million combat hours, 5,222 P-47s were lost in action.

of a landing P-38 Lightning. "He was dead before he hit the ground," Charles Johnson wrote.

But it was the Battle of the Bulge—when the Germans penetrated deep into Belgium in December 1944, creating a "bulge" in the Allied line—that brought the immediacy of war to the 365th ground crews. Between bouts of bitter winter weather, each Thunderbolt was slashing at the German advance with several sorties a day. In addition to the steady work of maintaining and re-arming the Jugs, the ground crews pulled guard duty during the long, freezing nights, staying on the lookout for German infiltrators.

PHOTO BY TOM GLENN/ROBERT F. DORR COLLECTION

Auxiliary belly tanks were used to extend the Thunderbolts' range.

The temperature hovered near zero, recalls Alvin Bradley, and snow drifted so deep on the Hell Hawks' runway that crew chiefs had to repeatedly taxi a few fighters back and forth to blow the steel matting clear. James Hagan, a staff sergeant and crew chief with the 365th, remembers the frostbitten toes and fingers that came with the all-out effort to keep the P-47s in the air. Engine changes, refueling, re-arming: All were done outdoors in the snow and frozen mud.

The war's last frigid winter turned the demanding work of maintaining a Thunderbolt into an ordeal. Shilling remembers working through a brutally cold night with a fellow crew chief to change a P-47 carburetor—work too intricate for gloves. One worked, hands deep in the frigid engine, while the other warmed his frozen fingers over a makeshift ammo-box stove. Finally they got the job done. "The plane was shot down the next day," says Shilling.

When a mission returned, the crews shifted into high gear. "The planes were in varying condition: broken windows, oily windshields, bullet holes or flak tears here and there," wrote Johnson. If the pilots mishandled the throttle and water injection system on takeoff or in combat, they'd bring back blown cylinders and broken connecting rods. When leaks developed in valve cover gaskets, a fine film of oil sometimes sprayed back over the windscreen—a constant cause of complaints among the pilots.

Crews had to fill fuel and oil tanks, install drop tanks, and top off the water injection system next to the firewall (used to keep the fuel-air mixture from pre-igniting in the cylinders at high power settings). The armorers reloaded the wing bays with fresh belts of .50-caliber ammunition (about 300 rounds per gun) and wrestled a pair of 1,000-pound bombs into their underwing shackles. The crew chiefs and their assistants did most of the servicing, while flight and line chiefs assigned specialists to tackle battle damage or pilot squawks. The crews were lucky if they had an hour to get the P-47Ds back in the air.

As good as the big Pratt & Whitney engine was, maintaining it posed challenges. Jim Hagan remembers that changing spark plugs was a knuckle-buster: "You had to get your hand inside there, and there wasn't a whole lot of room."

"You worked from the time it was light until you couldn't see anymore," says Alvin Bradley. Add guard duty and other work details to flightline duties and the ground crews were working almost around the clock. And yet they took it in stride. "I was never tired," says Shilling. "There was just too much excitement."

By the fall of 1944, says Joy, "we were a well-oiled machine," handling three and sometimes four sorties a day.

Because the Ninth Air Force's fighter groups moved constantly to keep pace with the shifting frontlines, they seldom had adequate repair facilities. The 365th Fighter Group saw combat from March 1944 until May 1945. It hopscotched through England, France, Belgium, and finally Germany, occupying eight bases from D-Day to VE-Day. The group seldom enjoyed the luxury of even a bombed-out Luftwaffe hangar.

Frank Mangan, whose book details

HENRY YEAGER, COURTESY KAREN DUFFY

The less-than-glamorous life: In the standard field kitchen, cleaning up after dinner meant doing the dishes in garbage cans (right: Christmas, 1943). The brutal winter in the European theater made already spartan living even harder on the men stationed there.

his experiences as an armorer and photographer with the 50th Fighter Group, attributes the crews' ability to handle the relentless schedule to a simple desire to get the job done. "You got used to the routine," he says. He recalls thinking, "Here it is Christmas Eve, and the rest of the world is waiting for Santa, and I'm out here loading ammo! We didn't like it, but nobody bitched about it. Our attitude was 'Let's get this thing over with.' "

Rain turned the primitive airfields into quagmires, recalls Mangan. "Our bivouac area was a knee-deep sea of slippery, gooey muck. Mud stuck to our shoes and gathered more with each step until our feet looked like two big chunks of clay."

For ground crews and pilots, tent living was the rule; in Normandy the men were lucky to have a tarp stretched over a foxhole. For days on end, the crews' standard chow consisted of K- and C-rations, but if the group settled down for a few weeks, the men could fill their mess kits with hot meals from their own spartan field kitchens.

When work was done, says Staff Sergeant Ray Larson of the 406th, "we cleaned the grease and dirt from our hands with gasoline." Showers were a rare treat; Alvin Bradley remembers melting snow in his helmet and taking a sponge bath in the cold water. And when his buddies found themselves bunking in a bomb-scarred Luftwaffe barracks, Mangan writes, "We used champagne liberated from the cellar to flush the toilets—and it worked!"

During the war, the 365th Fighter Group lost 69 men in combat or in accidents, most of them pilots. The one thing a crew chief dreaded most was discovering his airplane and pilot had failed to return from a mission. Yet the ground crews couldn't afford to dwell on the loss. Don Shilling lost his pilot three days after D-Day. "You got over it in a hurry," he says. "You could not sit around and mope. You had to get [back] on the stick."

Charles Johnson wrote the following lines on November 28, 1944, the day his pilot, First Lieutenant John Fitzsimmonds, was killed by a flak burst over Julich, Germany, on his 84th combat mission. Johnson had waited at the runway for his return:

Where's the one that can't be seen?
Where's the one to make sixteen?
One by one, sighs of relief.
I stood alone in disbelief.
No words are said...the others know.

Johnson, who died last year, got it right. "That P-47 was one tough airplane," he said, "and I guess so were we."

U.S.A.F COURTESY NASM (SI NEG. #89-1633)

A 365th Thunderbolt makes a low-level pass above U.S. tanks on the move in France in late 1944.

By the end of the war, U.S. aircraft were occupying bases in Germany.

ROBERT F. DORR COLLECTION

Dennis Biela is used to working in tight spaces. As one of the pioneers of QuickTime VR photography, he often has to squeeze himself and his camera into some hard-to-reach place that a client wants to show off in full, 360-degree splendor—whether it's the interior of a Jaguar or the QTBug, a Volkswagen Beetle tricked out with computers and cameras that Biela drives around the country as a promotional stunt.

The photographer's latest and probably greatest gig is documenting the historic treasures in the National Air and Space Museum, including the Concorde, the SR-71 Blackbird, the *Freedom 7* Mercury capsule, and the *Enola Gay* (above), the B-29 Superfortress that dropped the first atomic bomb. By the time he's done, Biela will have photographed some 200 cockpits and other artifacts so

DENNIS BIELA

that museum-goers standing at interactive kiosks can see (virtually) inside the airplanes behind the ropes. A sampler is on the Web at *www.nasm.si.edu/interact/qtvr/*.

Covering the interior of the *Enola Gay* at high-resolution required taking 18 individual photos and stitching them together. The view is looking out the nose of the airplane from between the pilot's and copilot's seats, with the forward fuselage opening like a clamshell. The sky was added later.

A lifelong airplane aficionado, Biela (right, next to an Arado AR 234-B-2 Blitz jet bomber while demonstrating his technique to a group of aviation photographers), says that his favorite subject so far is not the Wright *Flyer*, nor the Apollo 11 capsule, but a Grumman G-22 Gulfhawk II. When he was seven years old, the Gulfhawk was one of Biela's most prized aviation flash cards.

ERIC LONG

Jack of All Planes

The Smell of Kerosene: A Test Pilot's Odyssey

by Donald L. Mallick with Peter W. Merlin. U.S. Government Printing Office, 2004. 252 pp., $22.

NASA DRYDEN

Don Mallick flew NASA's YF-12A Blackbird to study heat loads on supersonic aircraft.

In the exclusive pantheon of U.S. test pilots, no name shines with greater luster than Don Mallick. A Naval aviation cadet who learned to fly during the Korean War, he earned his wings in 1952 and went on to fly McDonnell's twin-jet F2H Banshee, made famous in the movie *The Bridges at Toko-ri*.

Mallick accumulated over 11,000 flying hours piloting over 125 aircraft types for the Navy, the National Advisory Committee for Aeronautics, and NASA. Along the way he earned an aeronautical engineering degree, graduated from the Air Force Test Pilot School, and sampled some of the most exotic airplanes ever built, including two Mach 2+ engines-with-wings: Lockheed's needle-nose F-104N Starfighter and Vought's rakish XF8U-3 Crusader. (The latter flew so fast its pilots had to limit the time spent at high speeds lest its canopy weaken from the prolonged heat.) And there were many others: a variable-stability North American F-100 Super Sabre; Vertol's VZ-2 tilt-rotor; NASA's first lifting body, the M2-F1; and the awe-inspiring XB-70A Valkyrie, the largest supersonic airplane ever flown.

Mallick was one of a small band of test pilots and flight test navigators who also flew Lockheed's extraordinary Mach 3 SR-71 Blackbird. Despite prolonged and unsettling problems with engine unstarts—when shock waves created by engine inlets would pop out of air intakes and create tremendous drag and violent motions—Mallick's love for Kelly Johnson's most memorable design clearly shows. Through it all, Mallick coped with aplomb, befitting a fellow of the exclusive Society of Experimental Test Pilots.

Aided by historian Peter Merlin, Mallick has written a book that is full of wonderful anecdotes and evocative photographs, and loaded with thoughtful insights and illuminating insider information on the golden age of U.S. flight testing. Sweeping from the immediate post-World War II era to the late cold war era of electronic flight controls and exotic supersonic aircraft, *The Smell of Kerosene* is a significant contribution to the literature on test pilots and flight testing.

—Richard P. Hallion is a senior advisor to the U.S. Air Force and co-author of On the Frontier, *the official history of NASA's Dryden Flight Research Center in California.*

Strange Angel: The Otherworldly Life of Rocket Scientist John Whiteside Parsons

by George Pendle. Harcourt, 2005. 250 pp., $25.

"Rocket scientist by day, black magician by night," could be a movie's tagline, but it also describes John Whiteside Parsons. While doing pioneering rocket work in the 1930s and 1940s, Parsons was a follower of magician Aleister Crowley, a man British tabloids named "the wickedest man in the world"

BRIEFLY MENTIONED

Beech 18: A Civil & Military History

by Robert K. Parmerter. Twin Beech 18 Society, 2004. 567 pp., $69.95.
Six pounds of information (that's 730 photos, 275,000 words) on the 60-plus versions of the iconic Beech 18.

because of his occult practices and reputation for debauchery.

Born in Los Angeles in 1914, Parsons was a science fiction fan who became interested in rockets and learned about chemistry while working at explosives plants. He never completed college, but he and like-minded rocket enthusiasts—"The Suicide Club"—formed an affiliation with the California Institute of Technology under the oversight of aerodynamicist Theodore von Kármán. Parsons developed the solid fuel used for the first successful tests of jet-assisted takeoff (JATO) and invented a castable solid fuel that paved the way for many of today's rockets and missiles.

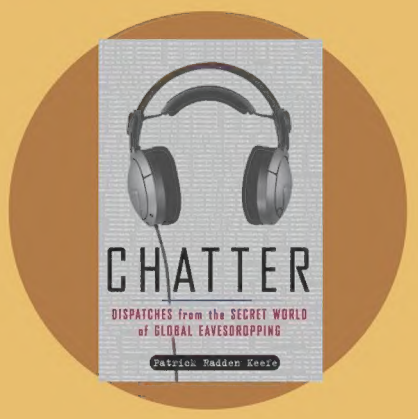
Intrigued by Crowley's writings, the handsome and charismatic Parsons immersed himself in the occult and embarked on a freewheeling communal existence in a decaying Pasadena mansion. There he cast spells and engaged in the kind of lifestyle suggested by Crowley's creed " 'Do what thou wilt' shall be the whole of the Law."

Parsons no longer fit into the increasingly buttoned-down world of rocketry. He became more obsessed with magic and unhappily entangled with another visionary, future Scientology founder L. Ron Hubbard, over a shared lover. In 1952, when he was 37, Parsons was injured in a horrendous chemical explosion, and died later.

Pendle tells an interesting story, but it feels like an extended footnote to a larger history. Hampered by a lack of primary sources—most of Parsons' papers are lost and his acquaintances dead—Pendle often paints with a broad brush and sprinkles his canvas with many a "perhaps," "may well have," and "it is possible." As a result, *Strange Angel* is less than fully satisfying.

—Tom Huntington is the former editor of American History *and* Historic Traveler *magazines.*

SHORT HOPS



Chatter: Dispatches from the Secret World of Global Eavesdropping

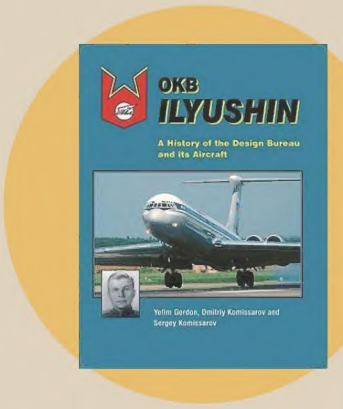
by Patrick Radden Keefe. Random House, 2005. 300 pp., $24.95.

This book could have been titled *Big Brother Takes to Space*. "Chatter" is spookspeak for electronic communication. Although there have been a number of books on observing Earth from orbiting satellites, those that describe eavesdropping satellites are rare. (James Bamford's *The Puzzle Palace* and *Body of Secrets* are notable exceptions.)

Patrick Keefe, a Yale law student, became intrigued years ago when he heard about a super-secret program called Echelon, which was heavily dependent on satellites that could listen in on voice communications. He has researched and written a highly informed and wonderfully readable book on the subject. And unlike the techno-junkies who usually work this beat, Keefe laces his writing with humor and wry observations. He also makes the important point that the rights of individuals to communicate with one another can clash with the overriding challenge of preventing terrorism.

But not being one of the initiated has made Keefe a little over-awed. Echelon is not some Orwellian system that hears absolutely everything. It tunes in to the voice chatter of individuals who are considered dangerous to the United States and its allies. My ordering out for pizza does not fall into that category.

—William E. Burrows



OKB Ilyushin: A History of the Design Bureau and its Aircraft

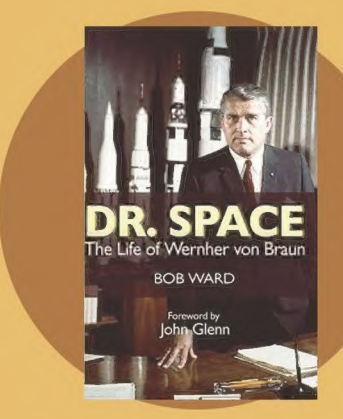
by Yefim Gordon, Sergey Komissarov, and Dmitriy Komissarov. Midland, 2004. 384 pp., $59.95.

In the course of Soviet history, several larger-than-life-figures personify the remarkable transformation of Russia from an agrarian society into a superpower. One of them is Sergey Ilyushin, the founder and head of the OKB-240 aircraft design bureau. The bureau produced its first airplane in 1936, and went on to lead the development of several generations of military and civilian aircraft that defined Soviet aviation history.

The volume opens with the history of the legendary attack aircraft the IL-2, the most recognizable symbol of Soviet air supremacy during World War II. Nicknamed a "flying tank" for its heavy armor and powerful cannon, the IL-2 devastated Nazi ground forces from Stalingrad to Berlin. The authors document the development and battle history of the IL-2, and include a rich selection of photos—some rare, some famous.

The book covers every design by Ilyushin's team before and after World War II, including the IL-22 experimental jet bomber; the IL-28 tactical bomber, infamous for its role in the Cuban missile crisis; and, finally, a lasting family of passenger airliners, which turned the OKB-240 design bureau into the Soviet equivalent of Boeing.

—Anatoly Zak



Dr. Space: The Life of Wernher von Braun

by Bob Ward. Naval Institute Press, 2005. 300 pp., $29.95.

Wernher von Braun was a precocious youth. His piano teacher was composer Paul Hindemith, and he assembled a jet-powered vehicle (six rockets lashed to a coaster wagon) at the age of 12. As the youthful chief of Germany's rocket program, von Braun got into trouble with his Nazi overlords because he talked of space travel when all they wanted from him was to drop explosives on their enemies' heads.

Von Braun led not only Germany into space—by way of the V-2 ballistic missile, which hammered London in the last year of World War II—but also the United States. His portable allegiances caused comedian Mort Sahl to quip, after seeing a von Braun biopic called *I Aim at the Stars*: "But sometimes I miss and hit London!"

This book is most interesting when dealing with the question of von Braun's war guilt. Von Braun was not just a Nazi, he was also an SS officer and head of a factory that employed slave labor. The story flags a bit (and so, in the end, did the seemingly indefatigable von Braun) amid the politics and bureaucracy of Fort Bliss, Texas, the Redstone Arsenal in Alabama, and NASA's Washington, D.C. headquarters. Still, this is a worthwhile biography of a fascinating man.

—Daniel Ford

Air & Space/Smithsonian magazine is now available on audio tape for members who cannot read standard print due to disability. For the basic membership fee, you will receive a print copy of the magazine plus the audio version. If you or someone you know has been struggling with the standard print version because of vision loss or other disabilities, contact the Smithsonian Accessibility Program at 1-888-783-0001 and receive your next issue of Air & Space on tape.

CALENDAR

June 2–5
Tunica Air Races and Airshow. World-class air racers will compete in the Unlimited, T-6, and Formula One classes. Tunica Airport, MS, (901) 674-0701, *www.tunicaairraces.com.*

June 11 & 12
P-51 Invitational. Observe P-51 Mustang formation flights and learn about World War II aviation. Warhawk Air Museum, Nampa, ID, (208) 465-6446.

World War II Heritage Festival. Richard I. Bong World War II Heritage Center, Superior, WI, (888) 816-9944, *www.bongheritagecenter.org.*

June 18
Air Fair. See a variety of airplanes and take part in educational aviation-related activities for all ages. Virginia Aviation Museum, Richmond International Airport, (804) 236-622, *vam.smv.org.*

July 8–10
Cape Girardeau Heroes and Legends Air Festival. Missouri Regional Airport, MO, (573) 334-6230, *www.capeairfestival.com.*

CREDITS

Operation Provide Feline. Greg "Blotto" Garrett flew F-16s with the 14th Tactical Fighter Squadron and 512th Fighter Squadron. Following his second operational tour, he went on to terrorize students and fellow instructors by flying T-38s at Reese Air Force Base in Lubbock, Texas.

Tear Down This Wall. Frequent contributor O.H. Billmann says that at 79 cents an hour, he was paid too much.

The Notorious Flight of Mathias Rust. Tom LeCompte is a Cambridge, Massachusetts-based freelance writer.

Confessions of a Spaceship Pilot. Brian Binnie is a program business manager and test pilot at Scaled Composites. He is a graduate of the U.S. Navy Test Pilot School at Patuxent River, Maryland.

Ring of Fire. James R. Chiles is the author of *Inviting Disaster: Lessons From the Edge of Technology* (Harper Collins, 2002).

Further reading: *Rings of Supersonic Steel*, Mark L. Morgan and Mark A. Berhow, Fort MacArthur Press, 2002.

Leroy's Launch. George C. Larson is the editor of *Air & Space/Smithsonian.*

Debrief: Hyper-X. Michael Milstein is an environment and science reporter at *The Oregonian* in Portland. For the Feb./Mar. issue of *Air & Space*, he wrote "Splashdown," a story about the crews who recovered astronauts and space capsules during the early years of NASA's manned space program.

The People and Planes of Creve Coeur. Linda Shiner is the executive editor of *Air & Space.*

Robo Repairmen. Michael Behar is a science and adventure-travel writer based in Arlington, Virginia. He has contributed to several publications, including *Outside*, *Wired*, and *Smithsonian.*

Cold Front. Thomas D. Jones flew U.S. Air Force B-52s and four missions on the space shuttle. His next book for Smithsonian-Harper is *Space Station Odyssey.*

Robert F. Dorr is an Air Force veteran, retired U.S. diplomat, and author. His latest book is *Chopper*, a history of helicopters in combat. He lives in Oakton, Virginia, with his family and dog.

FORECAST

In the Wings...

USAF (SI 79068)

Northrop's T-38 entered service in 1961 and is still on active (to put it mildly) duty.

White Rocket
"Like all objects of infatuation," our writer explains, "Northrop's T-38 has become encrusted with legend." Here's the truth about the trainer Air Force pilots love.

The Quiet Boom
Are supersonic passenger jets in our future?

Gravity Sounds Like This
Scientists are listening for proof of Einstein's general theory of relativity.

Prop-fan the Superhero
With scimitar-like blades, he was to have saved the airlines from piratical fuel prices. Where is Prop-fan when we need him?

ON THE WEB SITE

LIGHTSPEED MEDIA, LLC

WWII heavyweight: The P-47.

www.airspacemag.com

About a third of the 15,683 P-47s built during World War II ("Cold Front," p. 66) remained Stateside; among them, the Thunderbolt owned by the National Air and Space Museum. It was delivered on October 27, 1944, to Godman Field, Kentucky, and operated as an aerial gunnery trainer. Visit the Web for a close look—from cowling to tail wheel—at the heaviest Allied fighter of the war.

The Year's Most Memorable

Each year, dozens of record-setters unwittingly contribute to the continued fascination the public has with aviation. People may no longer be awed by a solo pilot's Atlantic crossing, but they are quite moved by a small rocket ship streaking across the sky to reach 100,000 kilometers (62 miles) above Earth. The National Aeronautic Association (NAA) records each such historic moment diligently, then compiles an annual list of the most memorable. Here, a selection:

COURTESY MATT BROOKS

The Cessna 501 Citation crew after their around-the-world, 114-hour jaunt.

Circumnavigating the globe, even with modern technological tools, is no easy task. So it was quite an accomplishment when Fred Lohden (chief pilot), Matt Brooks (flight commander), and Tim Weber (navigator) landed in Teterboro, New Jersey on May 17, 114 hours after they took off from that airport. The trio covered about 22,916 nautical miles (22,859 miles is considered "around the world") in a Cessna 501 Citation I/SP, a very small airplane, given the length of their journey. The record they set for Speed Around the World (westbound) stands at 199 mph. During the flight they made 23 stopovers in 17 countries, and overflew 39 countries.

SpaceShipOne captured the world's imagination when it flew into space (see Logbook, right). The first flight, on June 21, broke the X-15's longtime altitude record for an airplane launched from another aircraft. The Fédération Aéronautique Internationale recognized the SS1 team when pilots Mike Melvill and Brian Binnie each flew the spaceship successfully—their flights just 95 hours, 15 minutes, and 8 seconds apart.

Autogyros are a far cry from spaceships, but they manage to set records of their own. Andy Keech, for example, has been flying autogyros—an aircraft that resembles a helicopter and acts like an airplane—and setting records for many years. On April 20, he added yet another entry to his name: altitude record. He flew his yellow autogyro, nicknamed *Woodstock*, to 26,408 feet, beating a seven-year-old record by nearly 2,000 feet.

Part of the excitement of skydiving is the element of danger. True aficionados know there's more to it than just jumping out of a perfectly good airplane, as evidenced by a relatively new type of record set last year. Forty-two people gathered in Perris Valley, California, on April 30, to attempt a record for Largest Formation—Head Down. For the most part, skydivers free-fall with their bodies parallel to the ground. In this case, the record-breaking group dove head-down. And, more incredibly, they beat a record set in the recent past: 24 people diving head-down.

To classify as an ultralight, a glider must weigh less than 485 pounds, pilot included; the combination is far lighter than conventional gliders. Pilot Leonardo Benetti-Longhini flew his Alisport Silent 2 ultralight glider 390 miles to a Free Distance record, besting the previous total distance traveled in a straight line by 74 miles. At takeoff, Benetti-Longhini's empty aircraft weighed 280 pounds. The addition of his 150 pounds and 35 pounds of equipment put him 20 pounds under the limit.

Regardless of whether pilots were soaring into space or simply riding wind currents a few thousand feet above the ground, each person who set a record last year contributed to aviation history.

—Shannon Chambers

LOGBOOK

Trophy Flight

When SpaceShipOne flew into space in 2004, it became the first privately financed manned craft to do so, igniting the imaginations of people everywhere who have dreamed of space travel for the masses.

SpaceShipOne's place in aviation lore was recognized earlier this year when the team that designed and flew the aircraft (and its carrier, White Knight) won the prestigious Robert J. Collier Trophy (see Viewport, p. 4).

The National Air and Space Museum also recognized SS1's accomplishments when it awarded the prestigious NASM Trophy to Burt Rutan, his team, and financier Paul G. Allen at a black-tie dinner in March.

Burt Rutan's dreams of building a spaceplane date back to 1997, when he began designing SpaceShipOne. The spaceship is launched from the belly of White Knight (which was preceded by Proteus in the testing stages) at an altitude of 15 kilometers (50,000 feet).

SpaceShipOne fires its rocket engine for a 65-second burn in an 84-degree climb. Once the engine shuts down, the craft continues its ascent to 100 kilometers and then folds itself in half—Rutan's trademark "shuttlecock" configuration—at which point it glides back to Earth. SpaceShipOne's N-number, N328KF, represents the altitude goal of 328,000 feet. Their original choice, N100KM, had already been taken.

Rutan is by now a veteran award winner, having received the Collier Trophy in 1986 for his design of Voyager, the aircraft that made the first nonstop, non-refueled flight around the world. Three years later, his work with Voyager earned him the NASM Trophy as well.

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa-usa.org *or call (703) 527-0226.*